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1986

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FOREWORD

I am very pleased to provide introductory remarks for the 1986 Report of Activities. It is the purpose of the report to compile, in a single publication, summaries of the various field and laboratory projects carried out by the Nova Scotia Department of Mines and Energy.

Many of the projects described in this report were developed in co-operation with Energy, Mines and Resources Canada under a five-year, $26.9 million Subsidiary Agreement of Mineral Development. The work is designed to optimize, promote and encourage the orderly exploration for and development of the Province's mineral resources. It is important therefore that preliminary results are made available to the mining community as quickly as possible.

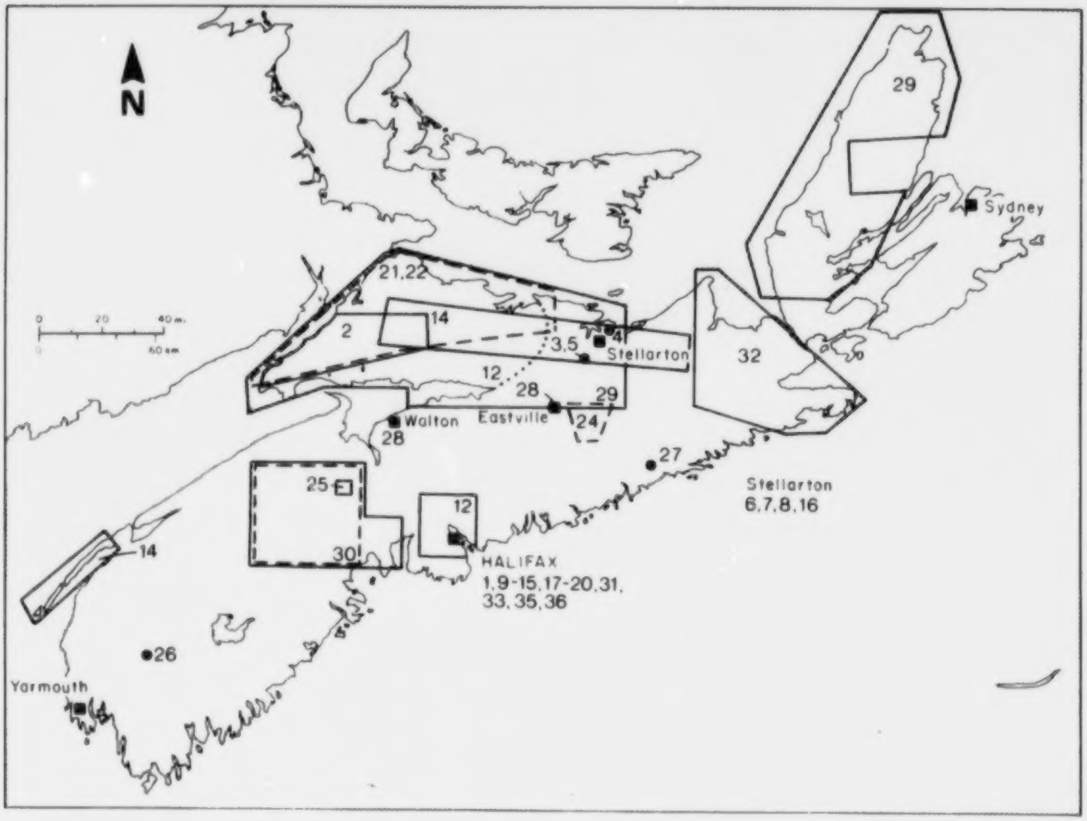
Although most of the projects are of immediate economic interest, others will be beneficial in the long term. For example, detailed studies related to gold should be of great assistance to the large number of companies and individuals currently exploring for this metal. Work which includes inventories of minerals such as gypsum, building stone and diatomite is important in the long term as it provides information on the size, grade and distribution of known deposits throughout the Province. Also, geological and geochemical studies are fundamental to the evaluation of our overall mineral resource potential. I am pleased that these technical and scientific studies are complemented by projects dealing with land use. Brochures and films designed to inform the general public of the importance of the mineral industry to the economy of Nova Scotia will also be supplied.

I hope the preliminary results of projects contained in this report are of interest to you and will assist you in assessing the geology and mineral resource potential of Nova Scotia.

Joel R. Matheson

Joel R. Matheson, Q.C.
Minister of Mines and Energy

NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY PROJECTS - 1986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Energy Resources Division

1.* Petroleum Update
2. Coal Depositional Study, Cumberland Basin
3,5. Stellarton Basin Oil Shale/Coal Project
4. Trenton Syncline Oil Shale/Coal Project

Mineral Development Division

6.* Exploration Monitoring
7.* Drill Core Library
8.* Gold Map Compilation
9.* Gold Commodity Project
10.* Industrial Minerals (encompasses projects 11 to 15)
11.* Gypsum and Anhydrite Project, Windsor Basins
12. Aggregate Resources Project
13.* Fillers
14. Diatomite Resources Project
15.* Building Stone Project
16.* Various Commodities
17.* Drillhole and Mineral Occurrence Databases Project
18.* Mineral Resource Promotion Project
19.* Land Use Policy Development Project

Mineral Resources Division

20.* Metallotectonic Map of Nova Scotia
21. Cumberland Basin Project
22. South Mountain Batholith Bedrock Mapping
23. Liscomb Project
24. South Mountain Batholith Mineral
25. Deposits Project
26. East Kemptville Project
27. Meguma Gold Project
28. Base Metal Project
29. Geochemical Stream Sediment Survey
30. South Mountain Batholith Pleistocene Survey

31, 32, 33 Quaternary Geology and Till Geochemistry

35. NSDME Computerization Study
36.* Education and Public Awareness

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*Province-wide projects

SUMMARY OF ACTIVITIES OF THE PETROLEUM RESOURCES SECTION, ENERGY RESOURCES DIVISION

P. J. Harvey, D. J. MacDonald and P. G. McMahon

Nova Scotia's petroleum industry experienced some notable bright spots during 1986 despite a worldwide slowdown throughout the industry due to low world oil prices. The following is an update of petroleum activities offshore and onshore Nova Scotia during the past year.

OFFSHORE

On August 26, 1986, the Governments of Nova Scotia and Canada signed the Canada - Nova Scotia Petroleum Resources Accord which replaced the 1982 Canada - Nova Scotia Offshore Agreement. The new Accord provides Nova Scotia with several significant improvements over the 1982 Agreement in the areas of development grants, future revenues, resource management and energy security. The Accord puts Nova Scotia on an equal footing with Canada in the management of the offshore resource and provides Nova Scotia with full control over revenues such as royalties.

During the past year, exploration activity resulted in the completion of nine wells by Shell Canada Resources Ltd., Mobil Oil Canada, Ltd., Petro-Canada Inc. and Husky/Bow Valley. Five of these wells evaluated new structures while four delineated existing fields. The West Olympia O-51 and North Triumph G-43 wells revealed significant gas in these new structures while Panuke B-90 struck significant oil in the Panuke structure (Fig. 1). Delineation drilling on the North Triumph, Glenelg, Cohasset and Thebaud fields was successful in extending the reserves over these structures. The Cohasset A-52 well further delineated the 1973 Cohasset oil discovery and yielded very encouraging test results which have revived interest in developing this field. The Thebaud C-74 well was very successful in adding additional reserves to the Thebaud field, one of the fields currently comprised by the Venture Gas Project.

The first Call for Nominations involving lands offshore was issued to the petroleum industry in February 1986 and resulted in the issuance of four parcels of land for bids (Fig. 2) which remained open until October 8, 1986. On November 7, one parcel of land was awarded to Petro-Canada and partners while a decision remained pending on the awarding of a second parcel of land. The decision is expected to be announced in early 1987.

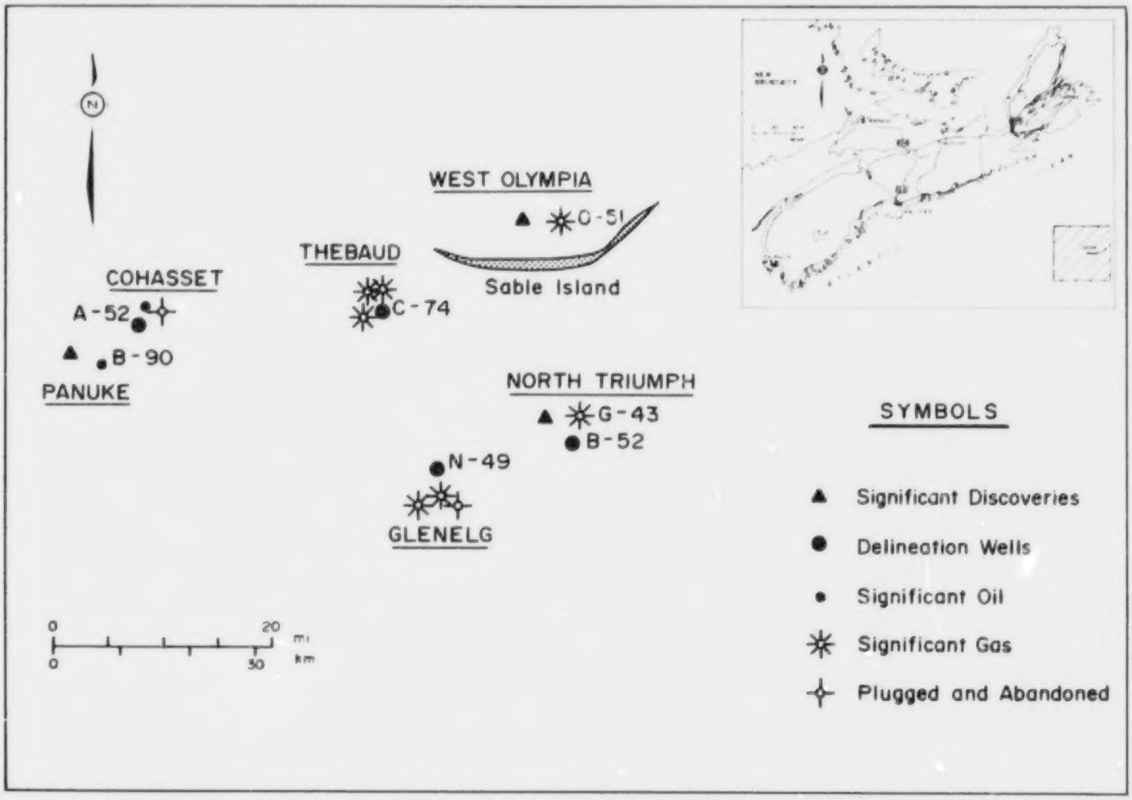

Figure 1. Summary of discovery and delineation wells completed during 1986.

NSDME Report 87-1

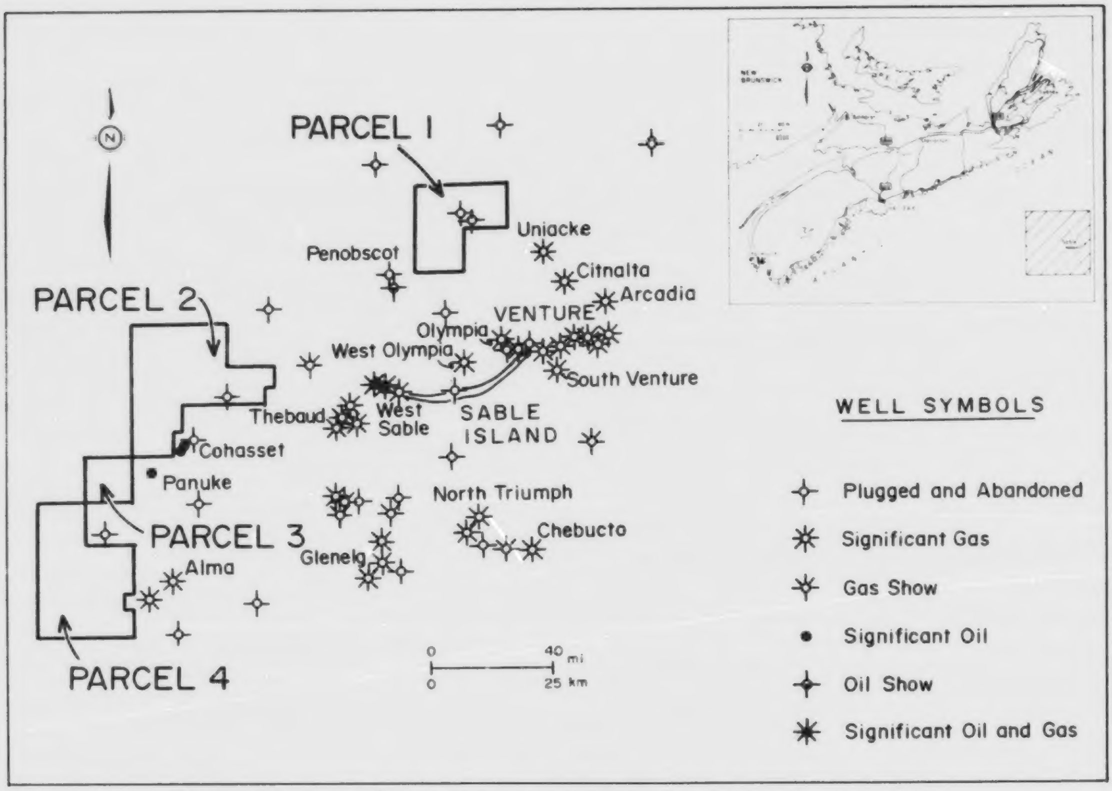
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Figure 2. Four blocks of land under Call for Proposals, June 1986.

In early 1986 a number of first round exploration agreements expired and the Canada - Nova Scotia Offshore Oil and Gas Board approved nine second round exploration agreements negotiated with Shell, Mobil, Dome Petroleum Ltd. and Husky Oil Operations Ltd.

During the past year, a screening document analyzing the impacts of oil and gas exploration on the environment and fishing industry on Georges Bank was prepared by the Federal Government at the request of the Canada - Nova Scotia Offshore Oil and Gas Board. This report was reviewed by the petroleum and fishing industries and public meetings were held in December 1986 throughout southwestern Nova Scotia between Texaco Canada Resources Ltd. and the fishing industry and made up the first part of its consultation program covering its proposal to drill on Georges Bank.

ONSHORE

Regulations governing the Nova Scotia Petroleum Resources Act for the administration of onshore oil and gas exploration and production were put in place October 30, 1985 and all former licencees had six months from this date to negotiate exploration agreements. By April 30, 1986, Chevron Canada Resources Limited, Irving Oil Limited, Sigma Resources Inc. and Miles negotiated exploration agreements that covered two-thirds of the land previously held under licences (Fig. 3). A further exploration agreement has been negotiated with Consultants A.G.R.E.N. Canada Inc. in the Kennetcook-Noel area of Nova Scotia. As part of A.G.R.E.N.'s work program requirement for the first year, a refraction survey was conducted during October and November 1986 over the agreement lands. Further work on these lands will depend on the results of the interpretation of this survey.

ONSHORE PETROLEUM DRILLHOLES AND SURFACE SHOW REPORTS

Exhaustive efforts have been made to search, record and verify data for two compendium publications: "Petroleum Wells, and Drillholes with Petroleum Significance Onshore Nova Scotia", Nova Scotia Department of Mines and Energy, Information Series #10, and "Surface Petroleum Shows Onshore Nova Scotia", Nova Scotia Department of Mines and Energy, Information Series # 11. Index maps and a glossary of terms are included in both reports. The drillhole report provides descriptions and reference sources for information on any wells and drillholes with petroleum significance drilled within Nova Scotia since 1869. Listed in this compilation are 97 holes drilled specifically in search of petroleum and data on another 68 drillholes which encountered some show of hydrocarbons. The companion report provides information and references concerning 25 "showings" of petroleum on the land surface. Among these are gas bubbling from various wells and blotches of petroleum at the surface. This report also describes oil which has been observed in mines as well as surface seeps and stains. It is hoped that the reports will be of some value to individuals and industry in assessing the petroleum potential of the onshore.

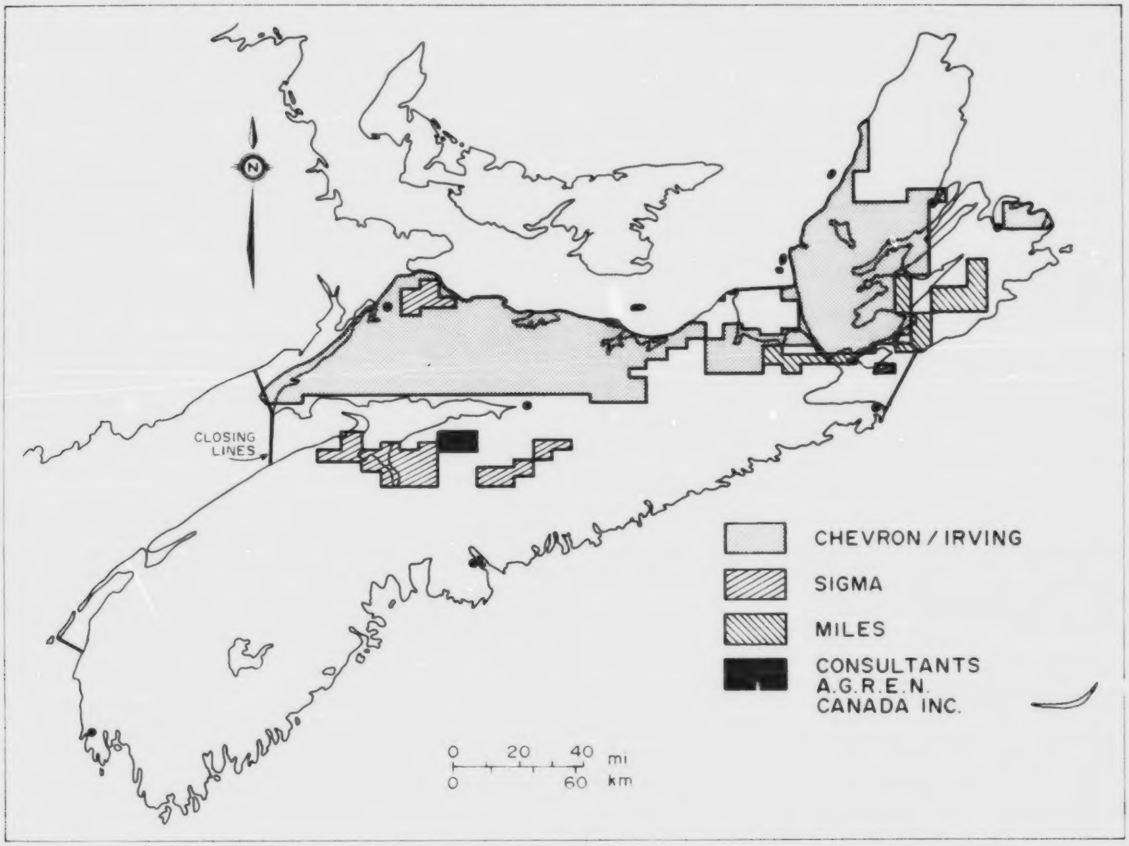
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Figure 3. Exploration agreements negotiated onshore Nova Scotia.

TECTONO-SEDIMENTARY EVOLUTION OF THE CUMBERLAND GROUP IN THE CUMBERLAND COAL BASIN: IMPLICATIONS FOR COAL EXPLORATION

J. H. Calder

There is a broad heirarchy of controls on coal deposition in the Springhill coalfield of the Cumberland coal basin or Athol Syncline (Calder, 1986). These controls affect the location, form and composition of the coal-forming mires (cf. swamps). A favourable climate, the tectonic framework, patterns of basin fill, neighbouring geomorphic regions and paleoecology of the mires all influenced groundwater distribution and therefore peat accumulation and preservation. These findings may have wide application to coal deposits elsewhere in the Cumberland Basin, particularly when linked with recent tectonic and sedimentological studies in the basin (Nance and Warner, 1986; Salas, 1986; Ryan et al., in press). In order to avoid confusion with the larger Cumberland Basin, the names Athol Syncline or "Athol Graben" (introduced here) are preferred to the ambiguous "Cumberland coal basin".

The primary objective in coal exploration is to locate coal deposits. In the Athol Syncline the coals are beneath a cover of younger overlapping strata. The location of the coal is believed to be a function of the tectonic setting and paleogeography of the basin (Calder, 1986). There is no consensus at present on the classification of the Cumberland Basin in terms of basin type (Boehner et al., 1986). Recent workers have referred to the Cumberland Basin during Westphalian B time as a pull-apart basin (Bradley, 1982; Mann et al., 1985; Keppie, 1982). Keppie (1982) placed this in the context of a regional "transpressional" system which had a later "foreland basin" stage during which the widely overlapping strata of the Pictou Group were deposited. In a recent thesis on the fluvial architecture of the Cumberland Group southwest of the Athol Syncline, Salas (1986) questioned the prevailing theory of strike-slip movement along the bounding faults and implied that the sedimentary record may alternatively be attributed to deposition in an intermontane, foreland, forearc, or predrift graben basin (after Miall, 1981). Ryan et al. (in press) suggest that the Athol Syncline may be a rhomb graben, or more correctly a tilted fault-wedge basin (Ryan, personal communication). The rhomb configuration requires a north-south trending basement fault, down-thrown to the west, east of the Springhill coalfield, proximal to and underlying the Black River diapir. Such an inferred fault may explain the abrupt western terminus of the Claremont Anticline and coincides with the northwest-southeast "hypothetical subsurface arch" of Copeland (1959).

Evidence in support of a sub-basin with an eastern boundary in this location may be found in the relationship between the Riversdale and overlying Cumberland Groups. Bell (1938) described a "marked angular unconformity" on the Black River between these two groups, however the precise contact is not exposed either on Black River or the tributary Deep Brook. A re-evaluation of this important section is currently being undertaken as part of the Springhill sheet mapping project. A detailed, small-scale geology map of the Springhill coalfield will be published which will be compatible with the larger scale Cumberland Basin maps of Boehner et al. (1987).

The implications of such a structural configuration are significant to the understanding of the basin-fill evolution and to coal deposition. A rhomb graben terminating near Salt Springs would have effectively constrained major subsidence and high rates of sedimentation to the Athol Syncline during the Westphalian B. The possibility that prerequisite conditions for peat mire development and preservation, such as a groundwater-fed piedmont (Calder, 1986), existed to the east of the Athol Syncline at that time would therefore be diminished.

Diapirism of Windsor Group evaporites and related strata has been cited as the chief factor in the origin of the Cumberland Basin coals (Shaw, 1951; Copeland, 1959; Hacquebard et al., 1967) and has been invoked by Hacquebard et al. (1967) to explain intra-seam depositional phenomena. Much of the evidence cited by these workers in support of major diapir-related topographic relief during coal deposition has been disputed (Calder, 1986). The possibility that incipient formation of the diapir in the subsurface, alluded to by Bell (1944), influenced subsidence and hence coal formation in the Springhill area is entirely plausible. Evaporites in the Cumberland Basin may have flowed preferentially along basement faults (Ryan, 1986), thereby increasing the potential influence of north-south faults east of Springhill.

Recent studies in southeastern New Brunswick (Nance and Warner, 1986) document early- to mid-Westphalian (A-C?) thrusting near the southwestern corner of the Cumberland Basin. This thrusting may have served as the driving mechanism of the easterly to northeasterly flowing braided trunk river system (Salas, 1986) which deposited the upper conglomerates of the Cumberland Group in the western part of the Athol Syncline.

Palynological samples were taken during the 1986 field season along the Sand River - Spicers Cove section (Divisions X and XI of Fletcher, 1908). Miospore studies (Dolby, 1984 and personal communication) indicate that this easterly flowing braided system and the contiguous coal-bearing strata at Spicers Cove were deposited in the early Westphalian C stage, contrasting with the late Westphalian B age of the coal-bearing strata in the Springhill coalfield. These relative ages generally agree with those determined by Hacquebard and Donaldson (1964) in their miospore studies. These results confirm that the braided trunk fluvial system exposed in the west of the Athol Syncline (cf. the "upper coarse facies" of Shaw, 1951) did not form a continuum with the earlier, longitudinal, internally braided-meandering trunk system (Calder, 1984) of the Springhill coalfield (cf. the "lower fine Facies" of Shaw, 1951) to the east (Fig. 1).

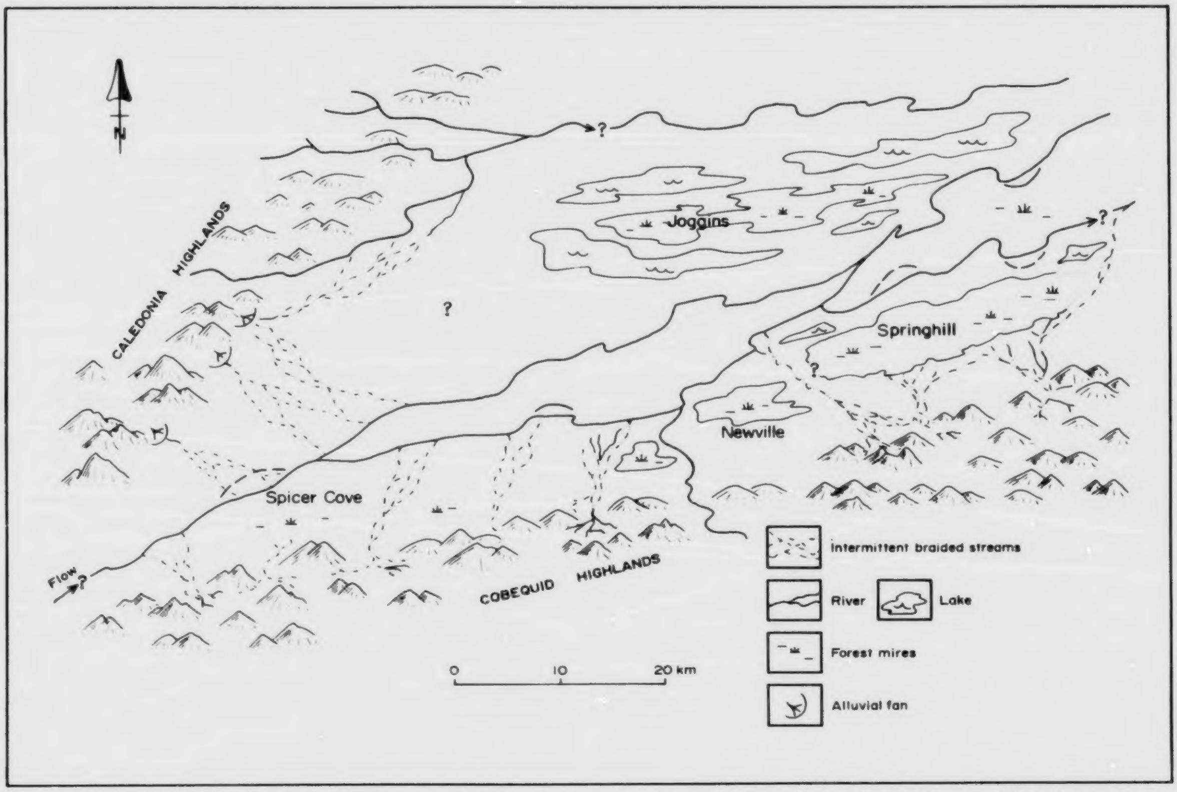

Figure 1. Schematic paleogeographic reconstruction of the western Cumberland Basin (Athol Syncline) circa late Westphalian B. Reconstruction depicts last vestiges of coal deposition in Joggins-Chignecto coalfield and earliest deposition at Springhill.

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MODELS FOR COAL EXPLORATION - TRENTON SYNCLINE AREA, NOVA SCOTIA*

A. M. D'Orsay, R. D. Naylor, W. D. Smith, M. C. Black and S. E. Palmer*****

Within the Trenton Syncline (Fig. 1) the Merigomish Formation of the Pictou Group (Yeo, 1985) is underlain by a thick sequence of Cumberland Group conglomerates, namely the New Glasgow Conglomerate (Bell, 1940). The purpose of this project was to test the thin coals of the Merigomish Formation for trends in thickening and quality improvement, and to determine if coal measures occur distal to the Cumberland Group conglomerates as reported in the Cumberland Basin (Calder, 1984).

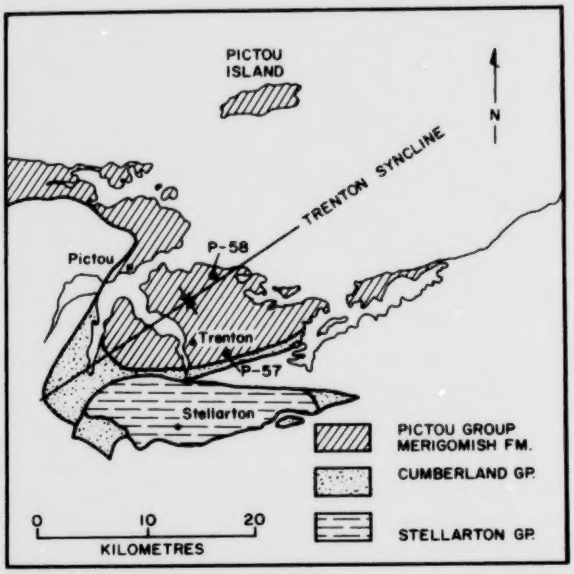

Figure 1. Geological map of the Trenton Syncline area showing the location of drillholes P57 and P58.

Two holes were drilled, P57 (147 m) and P58 (845 m), as part of the project (Fig. 1). During deposition of the New Glasgow Conglomerate and the Merigomish Formation, sediment dispersal directions were northwards (Yeo, 1985). Therefore P58 was assumed to occupy a more favourable location for coal exploration due to its distal position relative to P57. Figure 2 presents a simplified illustration and correlation of the stratigraphy intersected in drillholes P57 and P58.

No coal seams are present in either drillhole within the predominantly red New Glasgow Conglomerate. However, grey sandy beds, rooted zones and organic material become increasingly abundant near the base of drillhole P58. In P58, progradation of the New Glasgow Conglomerate is suggested by a coarsening and thickening upwards of conglomerate beds. In drillhole P57 the lowest stratigraphic member of the Merigomish Formation, the Smalls Brook Member, contains a basal stromatolitic limestone overlain by a grey lacustrine sequence of clastics and oil shales containing thin coals. In drillhole P58 the Smalls Brook Member is represented by a calcareous sandstone overlain by thin coals and rooted red mudstone, the latter of possible floodplain origin. The number, thickness and quality of the coal seams in P58 is reduced relative to P57. The Smalls Brook Member thins northerly, apparently the result of an erosional contact with the overlying Big Island Member (Fig. 2). The Big Island Member consists of a series of stacked channel sandstones of possible braided stream origin with intervening red and grey floodplain mudstones and siltstones. The Big Island Member, like the Smalls Brook Member, contains only a few thin coal seams.

FUTURE COAL EXPLORATION - TRENTON SYNCLINE AREA

CUMBERLAND GROUP

The coarse grained nature of the Cumberland Group rock units intersected in drillhole P58, coupled with the regional northward sediment dispersal directions, indicate future exploration for Cumberland Group coal should be north of P58. A possible location for testing for Cumberland Group coal measures would be Pictou Island (Fig. 1). The Pictou Group strata overlying the Cumberland Group on Pictou Island are relatively thin, allowing possible coal measures of the Cumberland Group to be cored at a mineable depth.

MERIGOMISH FORMATION

Within the Merigomish Formation, in the Smalls Brook Member, thick high quality coal might exist between drillholes P57 and P58. The occurrence of such coal would require peat-forming marginal swamp conditions to have existed in the area between the lacustrine environment suggested in drillhole P57 and the floodplain environment indicated in drillhole P58. Coal seams may be present at higher stratigraphic levels within the Smalls Brook Member where it has not been as extensively eroded by the Big Island Member. Areas away from the axis of the Trenton Syncline, where the Big

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*Funded by Nova Scotia Department of Mines and Energy and Geological Survey of Canada under the Canada - Nova Scotia Mineral Development Agreement

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***Saint Mary's University, Halifax, Nova Scotia

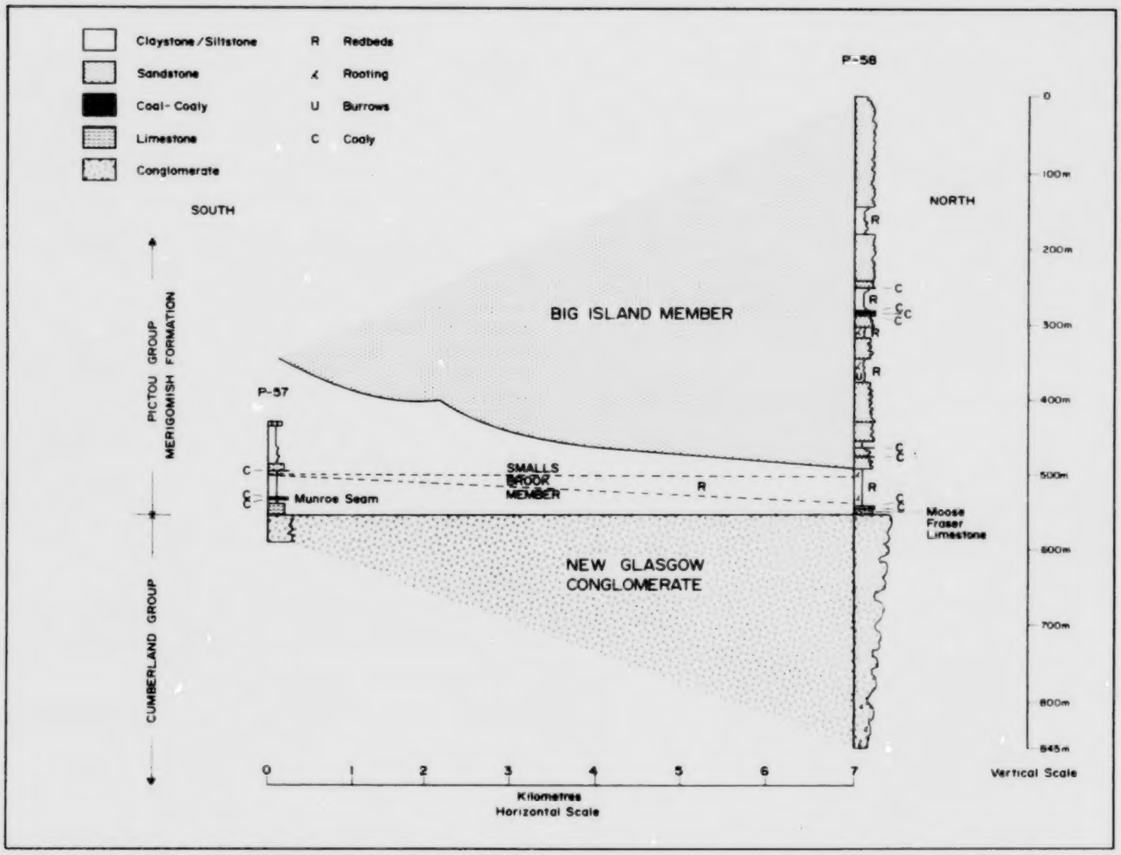
Claystone/Siltstone
Sandstone
Coal-Coaly
Limestone
Conglomerate
R Redbeds
Rooting
U Burrows
C Coaly
SOUTH
NORTH
P-57
P-58
PICTOU GROUP
MERIGOMISH FORMATION
CUMBERLAND GROUP
BIG ISLAND MEMBER
SMALLS BROOK MEMBER
Munroe Seam
Moose Fraser Limestone
NEW GLASGOW CONGLOMERATE
R
C
0
100m
200m
300m
400m
500m
600m
700m
800m
845m
Vertical Scale
0 1 2 3 4 5 6 7
Kilometres
Horizontal Scale

Figure 2. Stratigraphic correlation between drillholes P57 and P58, with the top of the New Glasgow Conglomerate used as a datum.

Island Member may thin, are potential targets for exploration.

The fluvial style of the Big Island Member is not conducive to the development or preservation of significant coal seams. Future coal exploration of the Big Island Member stratigraphic interval should concentrate on areas where a more mature fluvial system might have predominated.

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COMPUTERIZATION OF COAL EXPLORATION DATA FOR NOVA SCOTIA*

J. D. Hughes**, P. D. Watson*** and D. J. MacNeil

A co-operative project was initiated in February 1985 between the Geological Survey of Canada and the Nova Scotia Department of Mines and Energy to compile and verify coal exploration data for the Nova Scotia coalfields in a computer-processable format. Work on construction of computer files of coal geological and coal quality information continued in 1986 under the Canada - Nova Scotia Mineral Development Agreement (Fig. 1). For an outline of the rationale, procedures and objectives of the project, the reader is referred to Hughes et al. (1986).

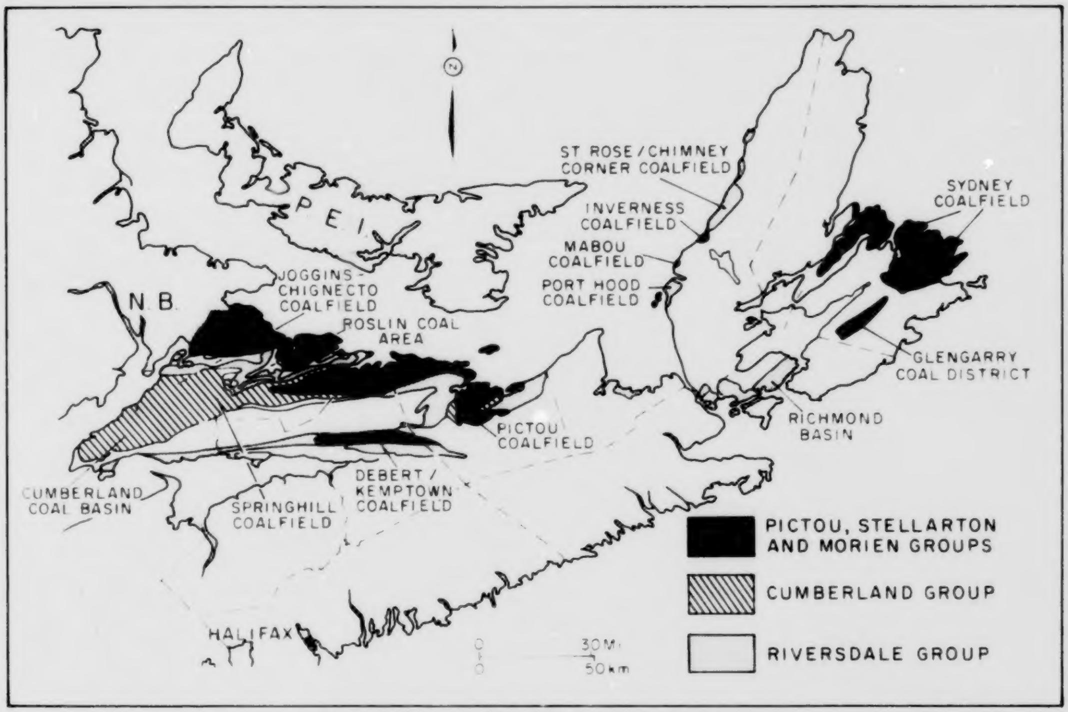
N
ST ROSE/CHIMNEY CORNER COALFIELD
SYDNEY COALFIELD
INVERNESS COALFIELD
MABOU COALFIELD
PORT HOOD COALFIELD
P.E.I.
N.B.
JOGGINS-CHIGNECTO COALFIELD
ROSLIN COAL AREA
GLENGARRY COAL DISTRICT
RICHMOND BASIN
PICTOU COALFIELD
CUMBERLAND COAL BASIN
SPRINGHILL COALFIELD
DEBERT / KEMPTOWN COALFIELD
HALIFAX
0 30 Mi
0 50 km
PICTOU, STELLARTON AND MORIEN GROUPS
CUMBERLAND GROUP
RIVERSDALE GROUP

Figure 1. Coalfields of Nova Scotia.

A two-person team in Halifax, consisting of a geologist and a technician, performs the data compilation and verification using database programs on the Geological Survey of Canada HP3000 computer in Calgary via an onsite terminal and Dataroute. Information from boreholes, outcrops and mining operations (including channel sample descriptions and analyses) is interpreted and rationalized using a well defined, consistent set of procedures and standardized descriptors. Data entry, modification and retrieval functions available for the database allow efficient input and editing. Entries are checked against a data dictionary or numeric range on input. Graphic strip logs (Fig. 2) and listings of the data are also generated for each location and compared with the original information for verification. For a detailed account of the methodologies used in interpretation, storage, retrieval, display, verification and manipulation of the data, the reader is referred to Hughes (1984).

The first phase of the project (fiscal year 1985-86) entailed construction of data files for the Sydney coalfield and other smaller coalfields of Cape Breton Island. Entry of data from 785 boreholes totalling 72 076 m, including analytical data for 929 samples from coal seam intersections, was completed. As well, coal quality data for some 2100 channel samples from underground mines were entered. Other information required for deposit modelling in the Sydney coalfield, such as detailed topographic, bathymetric and seafloor sediment maps, has been digitized and converted to a common co-ordinate base (6 UTM).

Work on the second year of the project (1986-87) involves construction of computer files

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*Funded by Geological Survey of Canada under the Canada - Nova Scotia Mineral Development Agreement
**Geological Survey of Canada, Institute of Sedimentary and Petroleum Geology, Calgary, Alberta
***c/o Energy Resources Division, Nova Scotia Department of Mines and Energy, Halifax, Nova Scotia

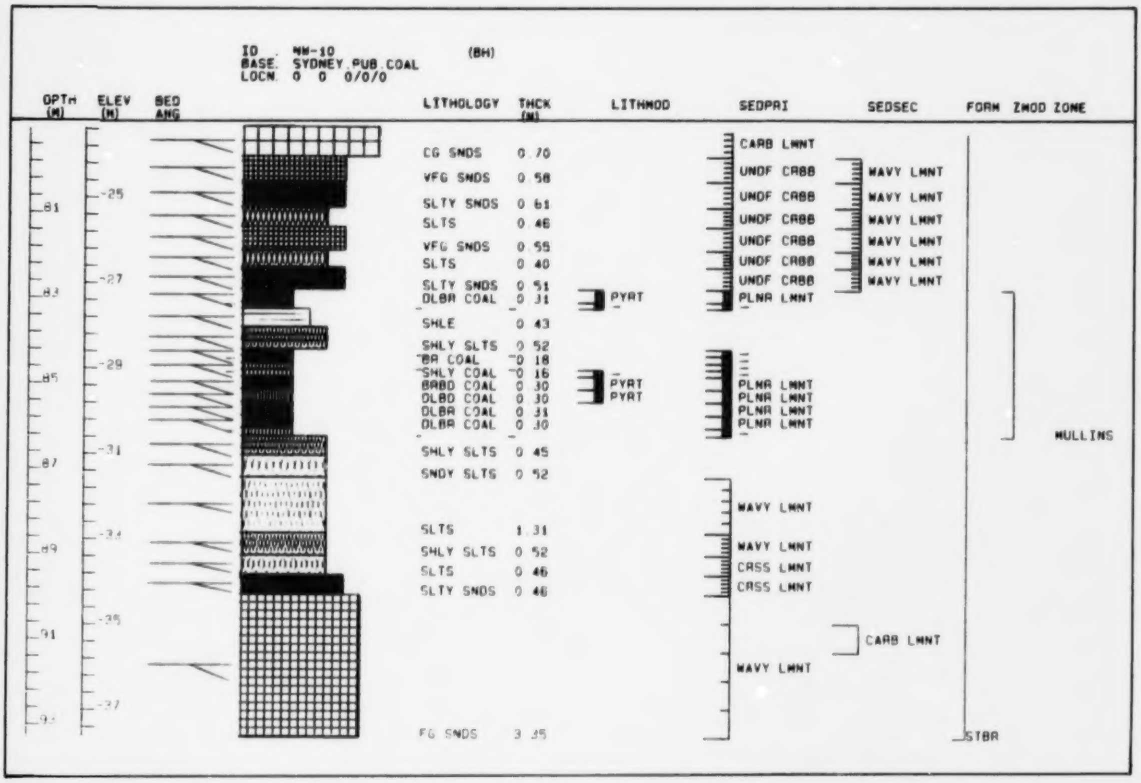
ID . NH-10 (BH)
BASE. SYDNEY PUB COAL
LOCN. 0 0 0/0/0
DPTH (M)
ELEV (M)
BED ANG
LITHOLOGY
THCK (M)
LITHMOD
SEDPRI
SEDSEC
FORM ZMOD ZONE
CG SNDS 0.70
VFG SNDS 0.58
SLTY SNDS 0.61
SLTS 0.46
VFG SNDS 0.55
SLTS 0.40
SLTY SNDS 0.51
DLBR COAL 0.31
SHLE 0.43
SHLY SLTS 0.52
BR COAL 0.18
SHLY COAL 0.16
BRBD COAL 0.30
DLBD COAL 0.30
DLBR COAL 0.31
DLBR COAL 0.30
SHLY SLTS 0.45
SNDY SLTS 0.52
SLTS 1.31
SHLY SLTS 0.52
SLTS 0.46
SLTY SNDS 0.46
FG SNDS 3.35
PYRT
CARB LMNT
UNDF CRBB
PLNR LMNT
WAVY LMNT
CRSS LMNT
MULLINS
STBR
81
83
85
87
89
91
93
-25
-27
-29
-31
-33
-35
-37

Figure 2. Computer-generated strip log of typical Sydney coalfield borehole.

for data from the Cumberland Basin coal districts and the Debert coalfield. Available information includes 395 boreholes totalling about 48 500 m, approximately 70 outcrop descriptions and 1250 coal sample analyses. Work will continue on entry of the remaining analytical data for the Sydney coalfield.

Nova Scotia Department of Mines and Energy Coal Section geologists have had occasion to use the retrieval and display capabilities of the system through the Geological Survey of Canada facilities in Calgary. As well, the Sydney coalfield database and associated programs were implemented on the Cape Breton Development Corporation computer in Glace Bay in July 1986. This is considered a first step in using the database to facilitate work in research and productivity of the coal industry in Nova Scotia.

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OIL SHALES OF THE STELLARTON BASIN, NOVA SCOTIA*

R. D. Naylor and W. D. Smith

The Pennsylvanian coal-bearing Stellarton Group, situated within the Stellarton Basin (Fig. 1), contains Nova Scotia's best known oil shale deposit. This deposit has been the focus of interest as a potential source of hydrocarbons since the 1850s (Douglas and Campbell, 1942). Only limited attempts have been made to identify the number and lateral continuity of oil shale units within the group and to differentiate them into lithotypes (e.g. How, 1868; Bell, 1940; Haites, 1956; Macauley and Ball, 1984). This information is important to an assessment of their potential economic use. Consequently, a study of the oil shales incorporating geological field mapping, core-logging, organic and inorganic geochemistry and organic petrology was initiated by the Nova Scotia Department of Mines and Energy (NSDME) in 1984. The following is a partial summary of observations and analytical results to date.

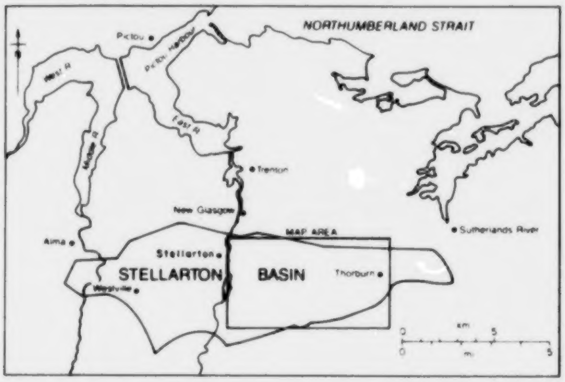
NORTHUMBERLAND STRAIT
Pictou
Pictou Harbour
West R.
East R.
Middle R.
Trenton
New Glasgow
Sutherlands River
MAP AREA
Alma
Stellarton
STELLARTON
BASIN
Thorburn
Westville
km
mi
0
5

Figure 1. Location map of the Stellarton Basin showing the map area for NSDME Open File Report 86-052.

A total of 45 laterally continuous oil shale units, averaging 5 m in thickness, have been identified within the Thorburn, Coal Brook and upper Albion Members of the Stellarton Group (Fig. 2). The oil shale units are silicate-rich (Naylor et al., 1986) and can be subdivided into lithotypes including carbonaceous shale, oil shales A, B and C and locally torbanite (Naylor et al., 1985). Each lithotype is characterized by distinctive megascopic properties (streak, fracture style, rock colour and appearance; Table 1). The lithotypes show increasing levels of organic content, chiefly exinitic organic matter, and decreasing specific gravity from carbonaceous shale through oil shales C-A to torbanite. Oil shale unit 45 contains stellarite, a friable, black, distinctly laminated and contorted oil shale lithotype. Stellarite is known only to this unit and analytical results are presently unavailable.

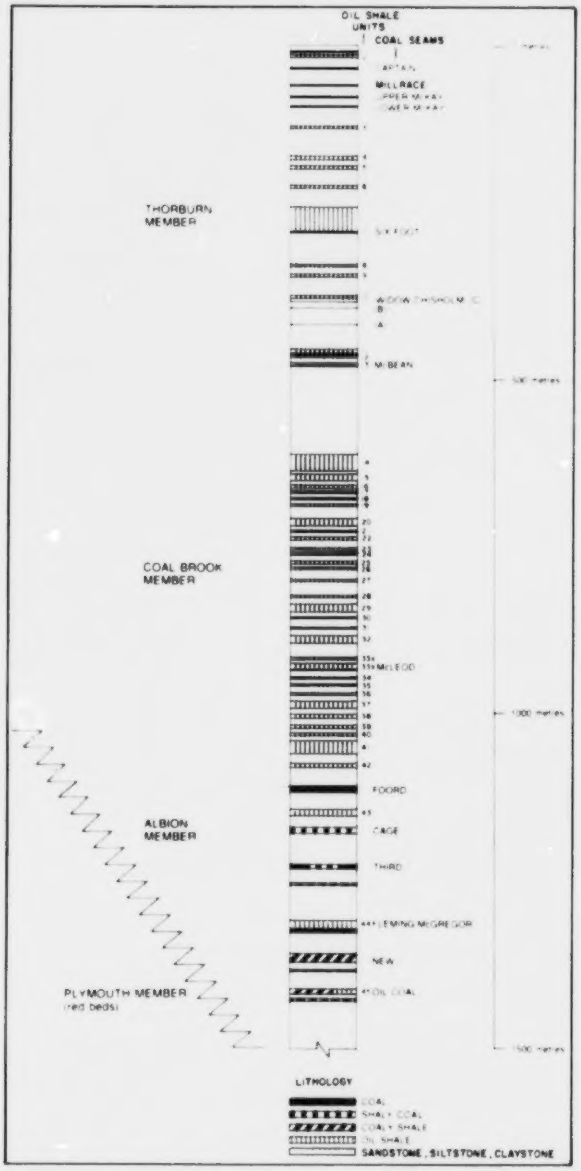
OIL SHALE UNITS
COAL SEAMS
CAPTAIN
MILLRACE
UPPER McKAY
LOWER McKAY
THORBURN MEMBER
SIX FOOT
WIDOW CHISHOLM C
B
A
McBEAN
500 metres
COAL BROOK MEMBER
McLEOD
1000 metres
FOORD
ALBION MEMBER
CAGE
THIRD
FLEMING McGREGOR
NEW
OIL COAL
PLYMOUTH MEMBER (red beds)
1500 metres
LITHOLOGY
COAL
SHALY COAL
COALY SHALE
OIL SHALE
SANDSTONE, SILTSTONE, CLAYSTONE

Figure 2. Stratigraphic column from the east side of the Stellarton Basin. Member names and boundaries after Bell (1940).

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

Coal seams locally pinch out laterally into units of oil shale (e.g. Six-Foot, McBean and McLeod seams) (Naylor et al., 1985; 1986). In vertical section coal/coaly shale is sharply overlain by cannel coal which grades upwards into oil shale C/B. In such coal to oil shale transitions, the overall organic carbon content of the lithotypes decreases (particularly humics) and the proportion of exinites in the organic component increases. Cannel coal is compositionally intermediate to coal and oil shale and is composed of about equal proportions of humics and exinites (Table 1). This coal to oil shale relationship suggests that a number of the other 42 oil shale units may be replaced laterally by coal seams and offers the potential for coal development in untested areas of the basin (Naylor et al., 1985; 1986).

Table 1. Lithotype classification scheme and results of the technical analyses summarized with respect to lithotype. SG = specific gravity, n = number of samples, n.d. = not determined and N/A = not applicable.

LITHOTYPE	COLOUR AND APPEARANCE	STREAK	AVE. S. G.	AVERAGE ORGANIC CONTENT	HYDROCARBONS		
					Average Conversion (%)	Average Yield (l/t)	Average s.g. of oil
Carbonaceous Shale (F_c)	Dark grey to black, local pale grey silty interbands. Contains siderite bands and nodules. Exhibits fissility	powdery, pale grey	2.66, n=8	3.40% TOC, n=8 2.9% Exinites 0.5% Humics	21.5, n=8	4.0, n=7	n.d.; insufficient oil yield for determination
Oil Shale C (O_C)	Dark grey to black, locally colour-banded dark grey and black. Exhibits sub-fissility.	waxy, dark grey	2.62, n=19	3.08% TOC, n=19 2.5% Exinites 0.6% Humics	29.8, n=19	6.7, n=18	0.868; light, n=2
Oil Shale B (O_B)	Black, exhibits sub-fissility	waxy, light brown	2.63, n=25	4.69% TOC, n=25 3.6% Exinites 1.1% Humics	29.7, n=25	10.7, n=23	0.887; light, n=8
Oil Shale A (O_A)	Black, exhibits sub-fissility.	waxy, dark brown	2.56, n=19	7.24% TOC, n=19 5.5% Exinites 1.7% Humics	33.3, n=19	16.0, n=12	0.886; light, n=11
Torbanite (O_{tbn})	Black with a bluish lustre, massive, tough, exhibits little fissility and a conchoidal fracture.	waxy, dark brown	2.16, n=6	21.00% TOC, n=6 18.3% Exinites 2.7% Humics	41.3, n=6	58.7, n=4	0.897; light, n=10
Cannel Coal (C_c)	Black with a greasy lustre, massive with local "coaly streaks", tough, exhibits a conchoidal fracture.	waxy, black	2.46, n=13	13.48% TOC, n=13 7.2% Exinites 6.3% Humics	24.5, n=13	17.8, n=9	0.895; light, n=4
Coal (C)	Black, micro-banded; dull, bright and dull-and bright-banded.	N/A	1.57, n=6	60.15% TOC, n=6 1.4% Exinites 58.8% Humics	23.8, n=6	83.9, n=3	0.994; heavy, n=3
Coaly Shale (C_f)	Black, thinly interbanded coal and shale; exhibits fissility.	N/A	2.20, n=4	15.65% TOC, n=5 Proportion of Exinites and Humics not determined	24.7, n=5	28.7, n=3	0.943; heavy, n=2

Light hydrocarbons are generated by pyrolysis in increasing amounts from carbonaceous shale through oil shale C-A to torbanite. High yields of heavy hydrocarbons are generated by pyrolysis of coaly shale and coal. Cannel coal gives moderate yields (intermediate to oil shale A and torbanite) of light hydrocarbons. Hydrocarbon yields show good correlation with megascopic lithotype and thus properties such as streak, fracture style and specific gravity can be used as a means of estimating hydrocarbon yield.

A report on the stratigraphy, lithology and composition of the Stellarton Group oil shales will be available in late 1986 as NSDME Open File Report 86-051. A related report on the stratigraphy and sedimentology of the Stellarton Group, including a geological map of the east half of the Stellarton Basin, as outlined in Figure 1, will also be available in late 1986, as NSDME Open File Report 86-052.

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THE USE OF OIL SHALES AS A GUIDE TO COAL EXPLORATION AT THE EASTERN END OF THE STELLARTON BASIN*

R. D. Naylor, W. D. Smith and M. C. Black

Recent investigations of the oil shale- and coal-bearing Stellarton Group suggest that undiscovered coal may exist at depth on the east side of the Stellarton Basin. Within the upper two members of the Stellarton Group, the Thorburn and Coal Brook Members (Fig. 1), coal seams which are well developed at the basin margins often pinch out under an oil shale unit in central basin areas.

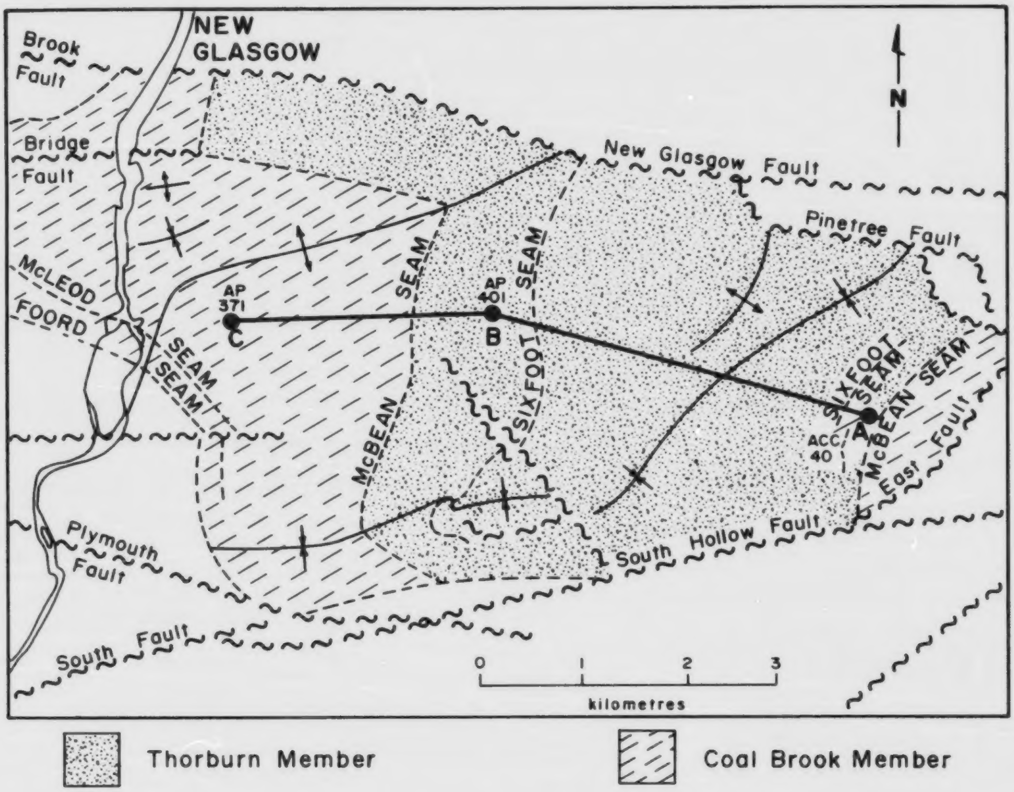
NEW GLASGOW
Brook Fault
Bridge Fault
McLEOD SEAM
FOORD SEAM
AP 371
C
AP 401
B
SEAM
SIXFOOT SEAM
McBEAN SEAM
New Glasgow Fault
Pinetree Fault
N
SIXFOOT SEAM
McBEAN SEAM
ACC 40
A
East Fault
South Hollow Fault
Plymouth Fault
South Fault
0 1 2 3
kilometres
Thorburn Member
Coal Brook Member

Figure 1. Geological map of the eastern end of Stellarton Basin showing the location of sections A-B and B-C.

Significant coal seams are known to directly underlie 3 of the 42 oil shale units of the Thorburn and Coal Brook Members. Section A - B (Fig. 2) illustrates that the Sixfoot and McBean seams (Thorburn Member) thicken eastward toward the basin margin but pinch out westward under oil shale units 7b and 13, respectively, toward the basin centre. Although the extensively mined Sixfoot and McBean seams can no longer be considered exploration targets, they serve to demonstrate that mineable coal seams occur under oil shale units toward the eastern margin of the Stellarton Basin.

The potential for finding additional significant coal underlying oil shale units within the Thorburn Member is limited as the majority of these oil shale units are laterally traceable to the eastern basin margin. In contrast, the potential for coal seams to have developed under the oil shale units of the Coal Brook Member has not been extensively tested. Section B - C (Fig. 3) illustrates that the McLeod seam, the only known coal seam of the Coal Brook Member, pinches out completely under oil shale unit 33 near the basin centre. To date, the McLeod seam has not been tested east of hole AP-401 (Figs. 2 and 3) for thickening and quality improvement trends. The McLeod seam holds excellent exploration potential if it continues to thicken to the east in a fashion similar to the Sixfoot and McBean seams. Also, the occurrence of rooted zones under a number of Coal Brook Member oil shale units in drillhole AP-401 suggests that coal may have developed eastward at these horizons near the basin margin.

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

In addition to the promising stratigraphic evidence, the interpreted paleogeography of the Coal Brook Member suggests that additional coal could have developed on the east side of the Stellarton Basin. During deposition of the Stellarton Group, lacustrine conditions predominated in the central Stellarton Basin with subordinate fluvial sedimentation occurring nearer the basin margins (Hacquebard and Donaldson, 1969). The distribution of coarser clastics, shown in Figures 2 and 3, strongly supports this interpretation.

The Stellarton Group oil shales are thought to have originated as hydrogen-rich organic material deposited in lakes (Macauley and Ball, 1984; Naylor et al., 1985) which were infilled largely by deltaic sediments (Naylor et al., 1985; 1986), namely the sandstone, siltstone and claystone of Figures 2 and 3. The coals underlying oil shales were probably formed on delta plain swamps which developed as the lakes were gradually infilled. During periods of restricted lake conditions algae and other hydrogen-rich organic material may have been deposited within the lakes while peat accumulated on the bordering

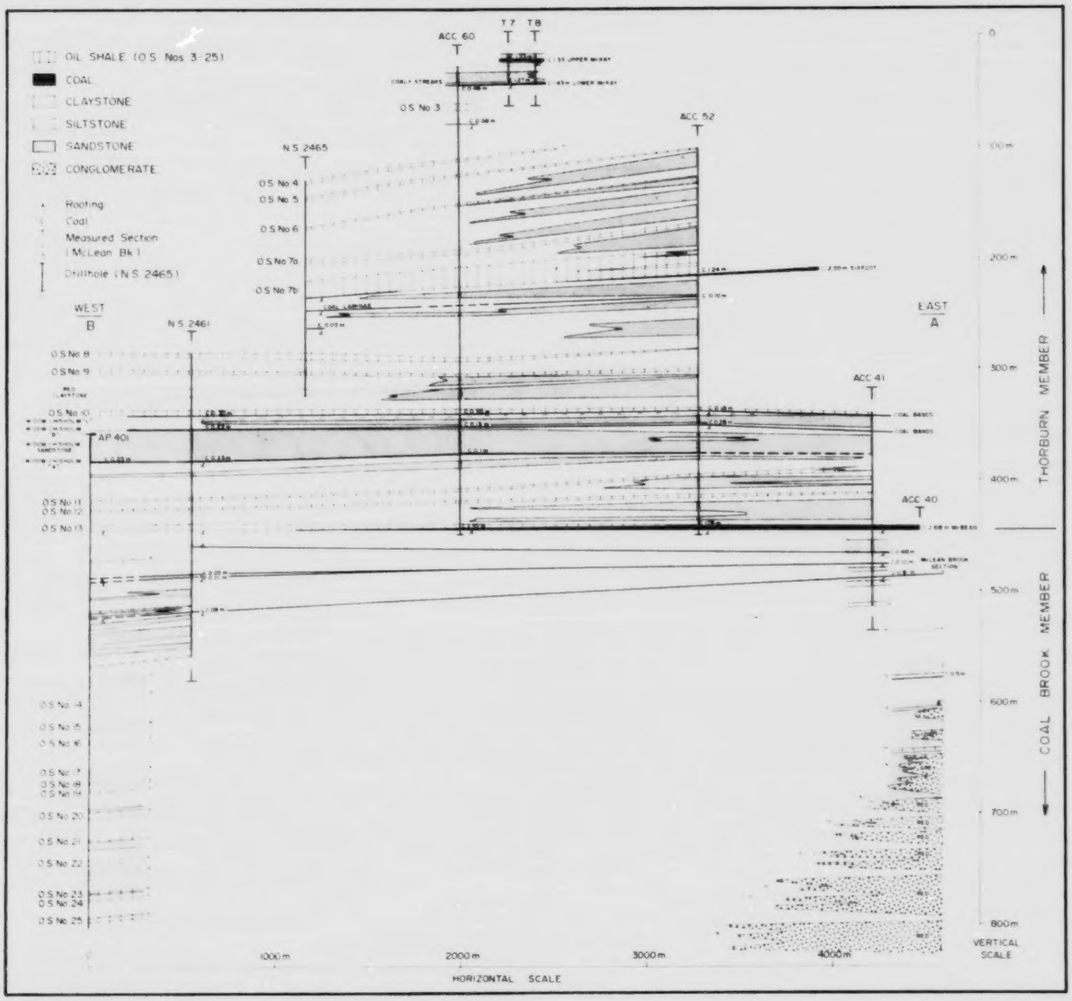
OIL SHALE (O S Nos 3-25)
COAL
CLAYSTONE
SILTSTONE
SANDSTONE
CONGLOMERATE
Rooting
Coal
Measured Section (McLean Bk)
Drillhole (N S 2465)
WEST
B
EAST
A
ACC 60
T 7
T 8
ACC 52
ACC 41
ACC 40
N S 2465
N S 2461
AP 401
COALY STREAKS
UPPER McKAY
LOWER McKAY
SIXFOOT
COAL LAMINAE
RED CLAYSTONE
COAL BANDS
McBEAN
McLEAN BROOK SECTION
O S No 3
O S No 4
O S No 5
O S No 6
O S No 7a
O S No 7b
O S No 8
O S No 9
O S No 10
O S No 11
O S No 12
O S No 13
O S No 14
O S No 15
O S No 16
O S No 17
O S No 18
O S No 19
O S No 20
O S No 21
O S No 22
O S No 23
O S No 24
O S No 25
0
100m
200m
300m
400m
500m
600m
700m
800m
VERTICAL SCALE
1000m
2000m
3000m
4000m
HORIZONTAL SCALE
THORBURN MEMBER
COAL BROOK MEMBER

Figure 2. Stratigraphic section (Section A - B) within Thorburn and Coal Brook Members using McBean seam as a datum.

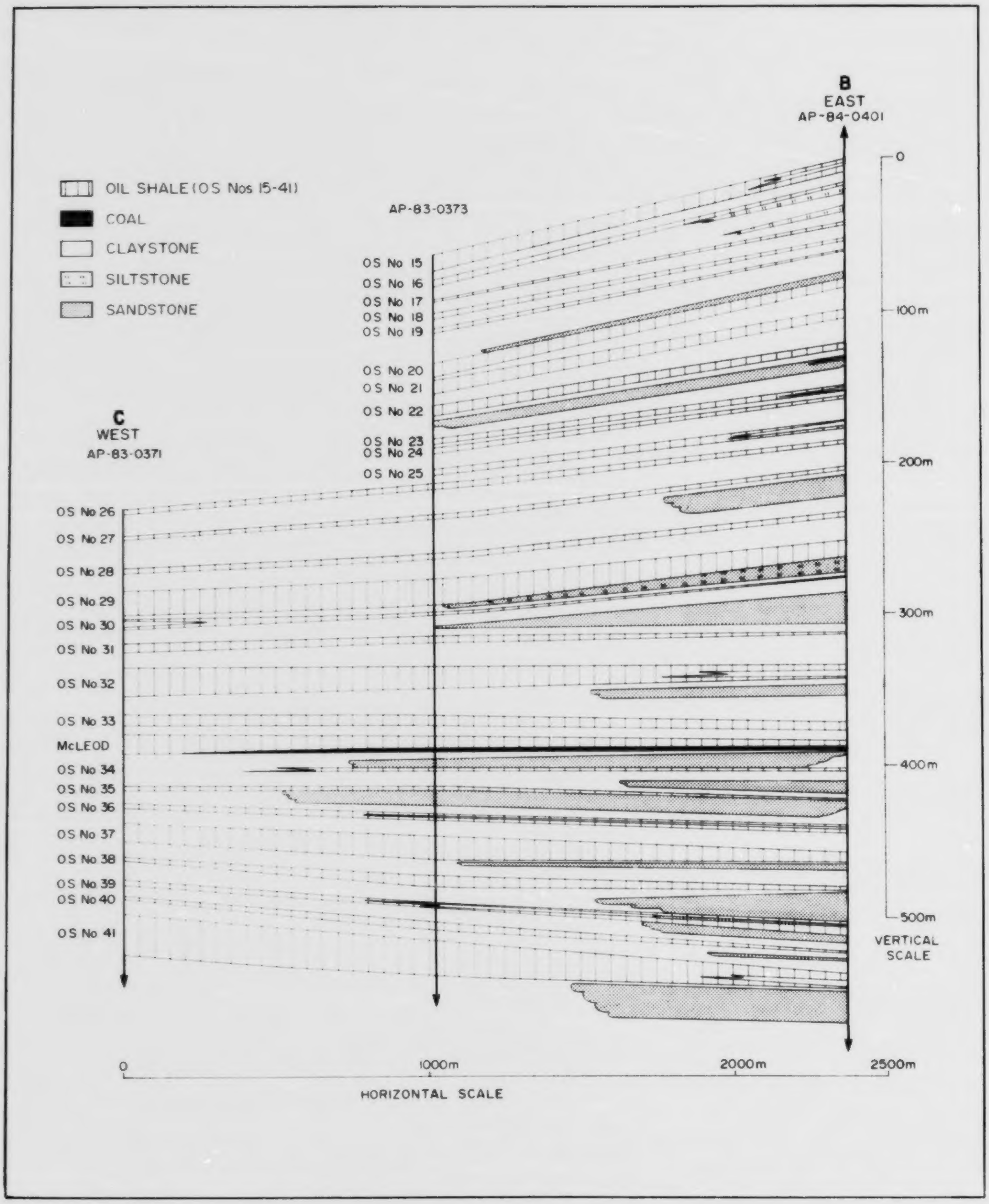
OIL SHALE (OS Nos 15-41)
COAL
CLAYSTONE
SILTSTONE
SANDSTONE
B
EAST
AP-84-0401
AP-83-0373
C
WEST
AP-83-0371
OS No 15
OS No 16
OS No 17
OS No 18
OS No 19
OS No 20
OS No 21
OS No 22
OS No 23
OS No 24
OS No 25
OS No 26
OS No 27
OS No 28
OS No 29
OS No 30
OS No 31
OS No 32
OS No 33
McLEOD
OS No 34
OS No 35
OS No 36
OS No 37
OS No 38
OS No 39
OS No 40
OS No 41
0
100m
200m
300m
400m
500m
VERTICAL SCALE
0
1000m
2000m
2500m
HORIZONTAL SCALE

Figure 3. Stratigraphic section (Section B - C) within the Coal Brook Member using McLeod seam as a datum.

delta plains. This suggests that coal seams and oil shales may have developed contemporaneously within the Stellarton Basin.

Detailed examination of Thorburn and Coal Brook Member coal to oil shale transitions shows that banded coal and coaly shale are abruptly overlain by cannel coal which is subsequently overlain by oil shale (Naylor and Smith, 1986). Interpretation of this vertical sequence indicates that increased infilling of lakes by sediment hindered basin drainage and resulted in subsequent flooding of the marginal swamps.

Based on the above, the development of significant coal seams below oil shale units east of drillhole AP-401 (Fig. 1) required that lakes remained restricted for long periods at the basin centre. The Sixfoot, McBean and McLeod seams provide evidence that such conditions did periodically exist during deposition of the Thorburn and Coal Brook Members.

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MINERAL EXPLORATION MONITORING ACTIVITIES

J. M. McMullin and P. D. McCulloch

INTRODUCTION

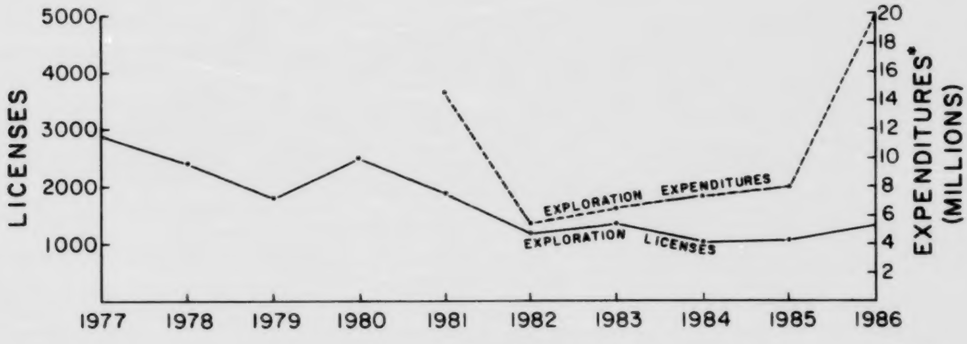
Monitoring of mineral exploration activity in Nova Scotia is the responsibility of the Resource Geology Section of the Mineral Development Division. Staff assigned to this program consists of a regional geologist and a project geologist based in the regional office at Stellarton, Pictou County.

The monitoring process includes regular visits to company offices and exploration sites, liaison with industry personnel and reviews of current assessment reports and other material submitted by industry. Direct liaison with industry allows the Department to maintain an awareness of current exploration activities throughout the Province. Problems and difficulties which may need to be addressed by the Department are identified and assistance or advice is provided if necessary. A statistical survey of exploration expenditures is compiled annually to obtain data on costs related to the various sectors of the mineral industry in the Province. For the purposes of exploration monitoring, "minerals" are considered to be any naturally occurring substances of potential economic value which would require a mining operation for extraction. This definition permits the monitoring of all exploration related activities, regardless of exceptions or special status under the Mineral Resources Act.

In addition, all diamond-drill core generated in the Province by the various mining exploration companies is recorded as part of the monitoring process. This core may be recovered for the Drill Core Library in Stellarton when no longer required by the companies.

MINERAL EXPLORATION ACTIVITY IN 1986

The pace of mineral exploration activity picked up dramatically in 1986, giving the industry its best year in Nova Scotia since the record setting years of 1980 and 1981. A preliminary estimate of $20 million is predicted for the cost of exploration work conducted in the Province for all minerals except petroleum during 1986, more than double the $9 million spent in 1985 (Table 1). Although the estimated 1986 expenditures were comparable to the $14.6 million spent in 1981 (Fig. 1) after allowing for inflation, gold exploration expenditures reached record levels because of the pronounced shift of focus toward precious metals and away from some of the commodities favoured at the beginning of the decade (potash, uranium and base metals). Given the favourable and stable price of gold during the year, two factors enhanced the attractiveness of Nova Scotia for gold exploration and increased the availability of money for these programs. The success of one Halifax-based junior company in quickly raising large amounts of exploration money and following through successfully by proving up substantial tonnages of ore-grade reserves attracted national attention, and the rapidly expanding availability of flow-through share financing for junior companies were both effective catalysts in attracting exploration to the Province.



EXPLORATION LICENCES ISSUED

*(1) All commodities excluding petroleum.
(2) Statistics not available for 1977-80.

Figure 1. Annual number of exploration licenses issued and levels of exploration expenditures.

Table 1. Mineral exploration trends in Nova Scotia.

Year		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Total exploration expenditures		NA	NA	NA	NA	14 607 662	5 552 675	6 500 000*	7 300 000*	9 000 000*	20 000 000*
Total licences issued - all categories		2 894	2 393	1 841	2 559	1 952	1 298	1 350	1 039	1 025	1 347
Current claims	General	70 936	38 597	40 497	88 703	68 863	39 626	40 630	26 627	27 809#	36 714#
	Coal	NA	NA	NA	NA	4 880	3 072	4 565	3 584	3 584	482
	Salt and Potash	887	1 148	2 256	13 505	5 225	1 065	505	1 257	830	306
	Uranium	48 721	31 978	30 920	25 483	6 225		(12 500) (closure)	(12 500) (closure)	(12 500) (closure)	(12,500) (closure)
	Total (including closures)	120 544	71 723	73 673	127 691	85 193	43 763	45 700	31 468	32 223	37 502
Total area held under licence (acres) (no adjustment made for multiple licences on the same ground)		4 821 760	2 868 920	2 946 920	5 107 640	3 407 720	1 750 520	1 828 000	1 258 720	1 334 560	1 468 568
Assessment work reported for licence renewals ($)		3 800 000	5 900 000	4 700 000	7 564 000	8 441 270	4 107 273	4 200 210	2 625 666	2 389 351	9 954 014
Number of assessment reports submitted		95	132	126	140	157	124	188	140	108	154

* preliminary figures
# includes tailings and development licence claims
NA not available

Although the number of claims held for salt and potash and for coal were substantially lower at the end of 1986 than a year earlier, the number of general claims in effect rose by 32% to 36,714 (Table 1). More than 200 individuals and companies held an interest (licences or options) in 1347 exploration, development or special licences during 1986 (Fig. 1), including 23 major, 25 junior and 30 private companies (Tables 2 and 3). In addition, several mining lease holders carried out exploration on their leases or on unclaimed ground where commodities such as limestone or gypsum did not require licences.

Eleven major and twenty-two junior companies were actively engaged in exploration for minerals during 1986, roughly the same as in 1985. No new exploration offices were opened during the year but several companies not previously active in Nova Scotia carried out exploration work during 1986. These included Four Seasons Resources Limited, Greenstrike Gold Corporation, Wilco Mining Company Limited and Torene Gold Explorations Incorporated.

Two major companies with regional exploration headquarters in Halifax, Esso Minerals Canada and U. S. Borax and Chemical Corporation (Pacific Coast Mines Limited), closed their offices in the latter part of the year.

The SCOMINEX joint venture completed its second full year with three of the original four members, Kennco Explorations Canada Limited having withdrawn from participation in SCOMINEX at the end of 1985. Sulpetro Minerals Limited was acquired during 1986 by Novamin Resources Incorporated (formerly Americ Mines Limited) and Kidd Creek Mines Limited was purchased by Falconbridge Limited in March 1986. Saarberg Interplan Canada Limited changed its name in 1986 to Interuranium Canada Limited.

Of particular significance to mineral exploration in Nova Scotia, the following companies maintained exploration offices in the Province in 1986. Companies in the Halifax area included BP Resources Canada Limited (Selco Division), Esso Minerals Canada, Granges Exploration Limited, Inco Limited (SCOMINEX), U. S. Borax and Chemical Corporation, Coxheath Gold Holdings Limited and Seabright Resources Incorporated. In other parts of the Province, Falconbridge Limited (Kidd Creek Mines Limited) was located in Windsor, the Acadia Mineral Ventures Limited, Cobequid Resources Limited and M. E. X. Explorations Limited group was located in Truro, and Suncor Incorporated was based in New Glasgow.

A total of 37,500 claims for all commodities were in effect at the end of 1986 under 1347 exploration, development and special licences, covering an area of nearly 1.5 million acres (approximately 5900 km^2), equivalent to about 11% of the total area of the Province. In addition, approximately 12,500 claims remained closed to exploration as a result of the uranium moratorium (approximately 2000 km^2).

MINING EXPLORATION

GOLD

Exploration for gold continued to dominate the search for metallic mineral deposits in the Province during 1986. A significant increase in the level of gold exploration was recorded in 1986 over 1985 with several large-scale exploration and development projects carried out through the year (Fig. 2). Some of these were new projects, primarily large drilling programs, with the remainder continued from the previous year. Most of the exploration for gold was carried out by junior companies with interest from major companies restricted primarily to regional grass-roots programs. The continued growth in gold exploration in the Province indicates that the current level of activity should extend into 1987.

Exploration was concentrated primarily on mainland Nova Scotia in the historic gold districts which host gold-bearing quartz veins in the Cambro-Ordovician metasedimentary rocks of the Meguma Group. The gold occurs in stratiform quartz veins and crosscutting fault structures (fissure veins) along the north and south limbs of northeast-trending anticlinal folds of the Goldenville Formation. The gold is free-milling and locally concentrated in discontinuous 'leads' and roll structures with associated arsenopyrite and other minor sulphide mineralization. Most of the production in the historic gold districts took place during the period 1860-1915 with the largest production (210,150 oz.) recorded from the Goldenville property in Guysborough County.

A number of new and continuing exploration programs were undertaken by the junior companies during 1986 with much of the activity concentrated in Halifax and Guysborough Counties. The programs included detailed geochemical and geophysical surveys, geological mapping, trenching and diamond-drilling.

Seabright Resources Incorporated continued a detailed surface exploration program and underground development work on the Forest Hill property in Guysborough County during 1986. Surface exploration, including diamond-drilling, was extended along the strike of the Schoolhouse and Ophir zones in conjunction with the underground development work. Detailed geochemical and geophysical surveys and geological mapping were also conducted on other areas of the property, primarily south of Forest Hill. The company also continued a detailed exploration program on the Beaver Dam property in Halifax County. Beginning in the fall of 1985 Seabright launched a large-scale drilling program, completing over 150 holes by the end of 1986. Detailed geochemical and geophysical surveys, geological mapping, and deep overburden sampling were undertaken on the property and regional surface exploration programs were carried out on adjoining ground, primarily to the northeast and east of the Beaver Dam property. Underground development work was also initiated on the property to facilitate bulk sampling of the Austin and Papke zones, and diamond-drilling continued to test the ore zones at depth.

Table 2. Major Companies with Interests in Mineral Exploration in Nova Scotia.

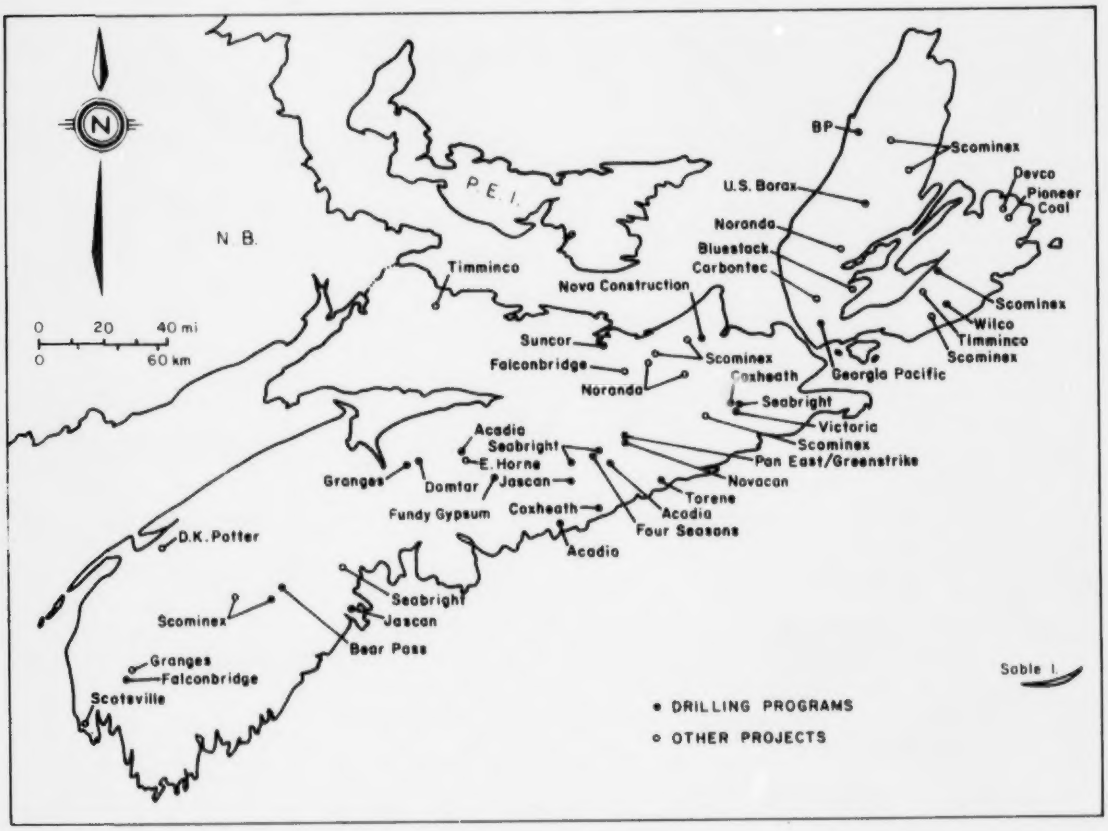
	1984	1985	1986	1986 Office Location
Billiton Canada Limited	x	-	-	
BP Resources Canada Ltd. (Selco Division)	x	x	x	Halifax
Canada Cement Lafarge Ltd.	x	x	x	Brookfield
Canada Offshore Resources Exploration Ltd. (through SCOMINEX)	x	x	x	
Canamax Resources Inc.	-	-	-	
Conwest Exploration Co. Ltd.	-	-	-	
Domtar Inc.	-	-	x	Windsor
Dow Chemical Canada Inc.	-	-	-	
Durham Resources Inc.	x	x	-	
Eldorado Resources Ltd. (ground alienation)	-	-	-	
Esso Minerals Canada	x	x	-	Halifax
Falconbridge Limited (Kidd Creek Mines Ltd.)	x	x	x	Windsor
Fundy Gypsum Company Ltd.	-	-	x	
Getty Minerals Company Ltd.	-	-	-	
Granges Exploration Ltd.	-	-	-	
Husky Oil Operations Ltd. (through SCOMINEX)	x	x	x	
INCO Limited	x	x	x	Halifax
International Limestone Industries Ltd., Scotia Limestone Ltd.	x	x	x	
Interuranium Canada Ltd. (formerly Saarberg Interplan Canada Ltd.) (ground alienation)	-	-	-	
Kennco Explorations Canada Ltd.	x	x	-	
Kerr Addison Mines Ltd.	-	x	-	
Lacana Mining Corporation	x	-	-	
National Gypsum (Canada) Ltd.	-	-	x	
Noranda Exploration Co. Ltd.	x	x	x	
Nova Construction Company, Pioneer Coal Co.	x	x	x	
Novacorp Engineering Services Ltd.	x	x	-	Halifax
Novamin Resources Inc.*	-	-	-	
Nova Scotia Sand and Gravel Ltd., L. W. Shaw	x	x	x	
Petro-Canada Resources Inc.	x	-	-	
Republic Gypsum Company	-	x	x	
Rio Algom Exploration Inc.	x	-	-	
Rio Algom Limited	x	x	-	East Kemptville
Shell Canada Resources Ltd. (ground alienation)	-	-	-	
Suncor Inc.	x	x	x	New Glasgow
Timminco Limited (Chromasco)	-	-	x	
U. S. Borax & Chemical Corporation (Pacific Coast Mines)	x	x	x	Halifax
Westmin Resources Ltd.	x	-	-	

x indicates field work performed
- inactive
* formerly Sulpetro Minerals Ltd.

Table 3. Junior and Private Exploration Companies Operating in Nova Scotia.

	1984	1985	1986	1986 Office Location
Acadian Gold Mines Ltd.	-	x	-	
Acadia Mineral Ventures Ltd.	x	x	x	Truro
Anglo Canadian Mining Corp.	x	-	-	
Athol Exploration Syndicate*	x	-	-	
Bear Pass Resources Corp.	-	x	x	
Bigstone Minerals Ltd.	x	x	-	
Bluestack Resources Ltd.	x	-	x	
Bras d'Or Syndicate*	x	-	-	
Carbontech Industries Ltd.	-	-	x	Halifax
Cobequid Resources Ltd.	-	x	x	Truro
Coxheath Gold Holdings Ltd.	x	x	x	Bedford
Cumbercoal Limited	-	x	-	Dartmouth
Cuvier Mines Inc.	x	x	-	Truro
Entrepreneurial Management Ltd.**	x	-	-	Bedford
Four Seasons Resources Ltd.	-	-	x	
Gold Brook Developments Ltd.	x	x	-	Margaree
Goldenville Explorations Ltd.	x	x	-	
Greenstrike Gold Corp.	-	-	x	
International Makaoo Ltd.	x	-	-	
Isaac's Harbour Gold Explorations Inc.	x	-	-	
Jascan Resources Inc.	-	x	x	
John A. Leslie & Associates Ltd.	x	x	x	Bedford
Kelrock Limited	x	x	x	Antigonish
Lake Mine Resources Inc.	x	-	-	
Lodestone Limited	-	-	x	Halifax
Lynx-Canada Explorations Ltd.	x	-	-	
Megaflo Resources Ltd.	-	x	-	
Meguma Gold Corporation Ltd.**	x	x	-	Bedford
MER Resources Inc.	x	x	x	Dartmouth
M. E. X. Exploration Ltd.	x	x	x	Truro
Middle Belt Mines Ltd.	x	-	-	
Mid-North Resources Ltd.	-	x	-	
Mono Gold Mines Inc.	-	x	-	
Northumberland Mines Ltd.	-	x	x	
Novacan Mining Resources (1985) Ltd.	-	-	x	Halifax
Oceanways Minerals Development Corp.	x	-	-	Dartmouth
Oldham Resources Ltd.	x	x	x	Dartmouth
Onitap Resources Inc.	x	x	-	
Outland Resources Corp.	x	x	x	
Pan East Resources Inc.	-	x	x	
Scotsville Mineral Resources Ltd.	x	x	-	
Seabright Resources Inc.	x	x	x	Halifax
The Potter Mine (Nova Scotia)	-	-	x	
Torene Gold Explorations Inc. Ltd.	-	-	x	Halifax
Tournigan Mining Exploration Ltd.	-	x	-	
Trafalgar Resource Investments Ltd.	-	-	-	
Tri-Explorations Ltd.	x	x	x	Dartmouth
Victoria County Explorations Inc.	x	x	-	
Victoria Resource Corp.	-	x	x	
W. Bruce Dunlop Ltd. NPL	x	x	x	
Wilco Mining Company Ltd.	-	-	x	

* now Jascan Resources Inc.
** now Coxheath Gold Holdings Ltd.
x indicates field work performed
- inactive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Falconbridge
Scominex
Coxheath
Georgia Pacific
Noranda
Seabright
Victoria
Scominex
Pan East/Greenstrike
Novacan
Torene
Acadia
Four Seasons
Acadia
Seabright
E. Horne
Jascan
Granges
Domtar
Fundy Gypsum
Coxheath
Acadia
D.K. Potter
Seabright
Jascan
Bear Pass
Scominex
Granges
Falconbridge
Scotsville
Sable I.
● DRILLING PROGRAMS
○ OTHER PROJECTS

Figure 2. Location of principal exploration/development projects in Nova Scotia, 1986.

Additional work by Seabright focused chiefly on the Moose River gold district west of Beaver Dam. A detailed surface exploration program continued on the property in 1986 and included ground geophysical surveys and a diamond-drilling program. Twenty-nine holes were completed in an initial phase of drilling during the summer. A second phase of drilling was resumed in late November. A detailed examination of the Lake Charlotte gold property, under license to Middle Belt Mines Limited, was also undertaken by Seabright during August. Work consisted of geological mapping and prospecting, geochemical and geophysical surveys, and trenching. A small surface exploration program was performed by the company at Gold River, Lunenburg County.

Under an option agreement with Northumberland Mines Limited, the SCOMINEX group initiated an underground bulk sampling and diamond-drilling program on the Cochrane Hill gold property in Guysborough County. Inco Limited is managing the program and expects to complete the project early in 1987. A diamond-drilling program totalling 8 holes was carried out by the SCOMINEX group on the Molega gold property in Queens County. The work was continued in the second year of an option agreement with Fred Rhodenizer who holds a development license on the property. A reconnaissance exploration program for gold was also undertaken by the SCOMINEX group in the Caledonia area, Queens County, 15 km west of the Molega propery.

A diamond-drilling program totalling 25 holes was undertaken by Coxheath Gold Holdings Limited on the Tangier gold property 25 km west of Sheet Harbour. The company has outlined significant gold mineralization in the immediate vicinity of the old workings and is planning to carry out underground bulk sampling of the ore zones early in 1987. Additional work was also done by Coxheath on the Mile Lake property approximately 2 km west of the Teasdale Mine at Forest Hill. Work consisted of detailed geochemical and geophysical surveys and a diamond-drilling program totalling 7 holes.

Novacan Mining Resources (1985) Limited carried out a detailed exploration program at Fifteen Mile Stream, Halifax County, consisting of geochemical and geophysical surveys, geological mapping, extensive trenching and diamond-drilling. Two phases of drilling were undertaken during the summer totalling 19 holes, and following the results of the initial work Novacan resumed drilling on the property in December. In conjunction with the work at Fifteen Mile Stream the company also completed reconnaissance work on claim groups to the south of the property. Pan East Resources Incorporated also resumed work at Fifteen Mile Stream in December, consisting of ground geophysical surveys and a diamond-drilling program totalling 3000 m along the north boundary of the Novacan property in the immediate vicinity of the old workings. The Pan East program is a joint venture project with Greenstrike Gold Corporation.

Acadia Mineral Ventures Limited carried out geochemical and geophysical surveys and a diamond-drilling program totalling 5 holes on the Renfrew gold property, Hants County, in an option agreement with Edgar Horne, the property owner. Acadia also completed drilling programs on the Clam Harbour gold property 5 km south of Lake Charlotte and the Killag gold property 10 km south of Beaver Dam in Halifax County. Cobequid Resources Limited, an associated company under Acadia management, initiated a surface exploration program on the Widow Point property at Country Harbour, Guysborough County, during the fall with plans to carry out a drilling program early in 1987.

Several additional gold exploration programs in the Meguma Group were completed or in progress by the end of 1986. Bear Pass Resources Corporation performed a diamond-drilling program totalling 20 holes on the Pleasant River Barrens gold property in Lunenburg County following the completion of a detailed surface exploration program in 1985. Jascan Resources Incorporated conducted a small surface exploration program, including trenching and diamond-drilling on the Indian Path gold-tungsten property, located 20 km southeast of Bridgewater, Lunenburg County. The company also completed trenching and a diamond-drilling program totalling 900 m on the Gold Lake (Scraggy Lake) property in Halifax County following the results of surface exploration in 1985. Torene Gold Explorations Incorporated completed additional drilling on the Harrigan Cove property 16 km east of Sheet Harbour in Halifax County. The company drilled an initial 900 m during the fall and resumed drilling again in December with plans to complete an additional 3000 m. Four Seasons Resources Limited carried out geochemical and geophysical surveys and a diamond-drilling program totalling 400 m on ground 1.5 km west of the Beaver Dam development project. Victoria Resource Corporation conducted a small surface exploration project including trenching and a diamond-drilling program totalling 450 m on the Mill Brook property 2 km south of the Forest Hill development in Guysborough County. Granges Exploration Limited carried out a small program of ground geophysics and diamond-drilling on the McKay Settlement gold property in Hants County.

Exploration for gold is also occurring in Cambrian and Hadrynian volcano-sedimentary rocks in other areas of the Province. These areas, which have been largely ignored in the past with respect to precious metals, include southeastern Cape Breton Island, the Cape Breton Highlands and the Antigonish Highlands. Recent exploration has included, in addition to property examinations, regional reconnaissance surveys to assess the highland areas for potential gold mineralization.

SCOMINEX (Scotian Mineral Exploration Venture), under the management of Inco Limited, entered the second year of a detailed evaluation of the Cambrian and Hadrynian volcano-sedimentary environments in several areas of the Province in 1986. Reconnaissance soil geochemical surveys, lithological sampling and geological mapping were undertaken primarily in the eastern regions of the Cape Breton Highlands. Detailed work was also carried out by the SCOMINEX group in southeastern Cape Breton Island to follow up results of reconnaissance work in 1985 covering the Fourchu Group. Detailed geochemical and geophysical surveys and a diamond-drilling program totalling 4 holes were completed on a property 8 km east of Big Pond, Cape Breton County. Noranda Exploration Company Limited continued a small-scale reconnaissance program in the Antigonish Highlands and completed a program of soil geochemical surveys and lithological sampling in the Whycocomagh area, Inverness County.

Detailed property examinations were conducted by several companies, primarily in the volcano-sedimentary rocks of the Cape Breton Highlands in Inverness County. BP Resources Canada Limited completed the second year of a detailed exploration program for gold and base metals in the Faribault Brook area 6 km east of Cheticamp. Work included detailed geochemical and geophysical surveys, geological mapping and prospecting, lithological sampling and a diamond-drilling program totalling 500 m. U. S. Borax carried out ground geophysical surveys and a diamond-drilling program totalling 500 m on ground 1.5 km east of the Second Gold Brook property near Middle River. Seabright Resources Incorporated also completed a diamond-drilling program near Farmington, Cumberland County, 55 km northwest of Truro in an area underlain by Silurian sedimentary and volcanic rocks.

In addition to the above programs several small-scale gold exploration projects were carried out throughout the Province (Tables 2 and 3) by various companies and individuals. This work consisted primarily of reconnaissance soil geochemical surveys, prospecting and lithological sampling.

BASE METALS

Exploration for base metals dropped significantly from 1985 levels due primarily to the collapse of tin prices and consistently low prices for the traditional base metals copper, lead and zinc. Consequently, only small-scale programs for tin were completed in 1986 and only those base metal properties with potential precious metal association received attention.

Exploration for tin was confined to the Devono-Carboniferous intrusives of the South Mountain Batholith southwest of the East Kemptville tin deposit. Falconbridge Limited conducted a diamond-drilling program totalling 200 m at Kempt Snare Lake as part of a follow-up program to assess work completed in 1985 by Kidd Creek Mines Limited. Falconbridge acquired the property as a result of the purchase of Kidd Creek Mines Limited in 1986. Granges Explorations Limited continued work consisting of geochemical surveys and geological mapping on ground held in the Peters Lake area 2.5 km southwest of Kempt Snare Lake.

Exploration for the traditional base metals was carried out in the Fourchu Group of southeastern Cape Breton Island and in similar age volcano-sedimentary rocks of the Cape Breton Highlands. Wilco Mining Company Limited initiated the second phase of a diamond-drilling program for gold and base metals on the Stirling property east of St. Peters in Cape Breton County. Initial drilling in the program was undertaken in 1984 by Bigstone Minerals Limited through a special licence held by A. D. Hunter. BP Resources Canada Limited completed the second year of a detailed exploration program for gold and base metals in the Faribault Brook area 6 km east of Cheticamp, Inverness County.

CELESTITE

Timminco Limited continued exploration for celestite on two separate properties during 1986 under the direction of A. C. A. Howe International Limited. Bulk samples taken in late 1985 from the Beckwith deposit in Cumberland County and on the Lake Enon deposit in Cape Breton County were processed for shipment. Diamond-drilling was also carried out on the Beckwith property following completion of the bulk sampling program.

WOLLASTONITE

An exploration program for wollastonite consisting of prospecting and detailed trenching was conducted on the Lime Hill zinc property, Inverness County, by Bluestack Resources Limited.

LIMESTONE

Canada Cement Lafarge Limited continued a detailed evaluation of several limestone deposits in the central mainland region of the Province during the year. Chapman Brothers of Souris, P. E. I., completed a diamond-drilling program at Pugwash, Cumberland County.

GYPSUM

Nova Construction Company Limited completed a detailed diamond-drilling program on a gypsum property at Brierly Brook, Antigonish County.

SILICA

An exploration program was carried out by Scotsville Mineral Resources Limited on the Chegoggin silica deposits north of Yarmouth, Yarmouth County, consisting of trenching and lithological sampling. Nova Scotia Sand and Gravel Limited completed additional bulk sampling of a silica sand prospect 1.5 km south of Elmsvale, Halifax County.

GRAPHITE

Exploration for graphite was undertaken by Carbontec Industries Limited on a property under license to Kelrock Limited at Glendale, Inverness County. Work consisted of ground geophysics and trenching.

MAGNETITE

Lodestone Limited completed an exploration program on a magnetite property at Bass River, Colchester County. Work included geological mapping, ground geophysics and trenching.

COAL AND OIL SHALE

The Nova Scotia Department of Mines and Energy continued a detailed assessment of the Pictou coal basin during the year. Exploration drilling was carried out in two areas including one drillhole at Frasers Mountain and another at Chance Harbour.

MINING DEVELOPMENT

GOLD

Seabright Resources Incorporated continued underground development work on the Forest Hill property in Guysborough County during 1986. A 230 m exploration shaft was completed early in the fall and 800 m of crosscutting and drifting were completed on the 200 m level by the end of November. Underground bulk samples were processed at the recently acquired plant facilities at Gays River. The company plans to continue development work on the 155 m level to facilitate a detailed evaluation of the drill-indicated ore reserves.

Seabright is also in the development phase of operations at the Beaver Dam property in Halifax County. The construction of a decline was started mid-year to access the main ore zones and crosscutting was started to facilitate underground bulk sampling. Since the beginning of the program in the fall of 1985, the company has drilled more than 150 holes. In addition to infill drilling Seabright tested the ore deposit at depths to 600 m. Published reserves in the proven and probable category as of October 29, 1986 were 1.56 million tons of ore grading 0.29 oz./ton gold.

GYPSUM

Several development projects were undertaken by gypsum producers in the Province during the year as part of a continuing program to develop gypsum reserves. Diamond-drilling was carried out by Domtar Construction Materials at McKay section, Hants County and Fundy Gypsum Company Limited at Dutch Settlement, Halifax County. Georgia Pacific Corporation also continued development drilling at Sugar Camp, Inverness County and preparations were underway to begin quarry operations shortly. Little Narrows Gypsum Company Limited began quarry operations at a new deposit at Little Narrows, Victoria County and Nova Construction Company Limited began production at a new quarry at Brierly Brook, Antigonish County.

STONE

Development work was carried out by B. MacKenzie on a sandstone quarry at Hardwood Hill, Pictou County, for various types of fill material.

COAL

The Cape Breton Development Corporation continued development work on two major projects in the Sydney coal basin during 1986. The work included driving of the main access slope at the Phalen mine as part of the Lingan/Phalen project. A second access slope was in construction at the Donkin/Morien mine.

Pioneer Coal Company, a subsidiary of Nova Scotia Construction Company Limited of Antigonish, carried out development work consisting of diamond-drilling and the preparation of an open pit operation on the Gardiner Seam at Reserve Mines, Cape Breton County.

Suncor Incorporated continued development work on the Stellarton coal project consisting primarily of diamond-drilling and geotechnical studies. Detailed feasibility studies on future mine development have been undertaken on the project since 1985 with a production decision expected shortly.

DRILL CORE LIBRARY*

J. M. McMullin and J. D. Langille

The Nova Scotia Department of Mines and Energy (NSDME) maintains core library/storage facilities at four locations in the Province. Two locations are in Stellarton, Pictou County (at the NSDME regional office on Bridge Avenue and in the Industrial Park), one in the Debert Industrial Park, Colchester County, and one near Malagawatch, Inverness County.

The main facility is in the Stellarton Industrial Park (Fig. 1) and consists of three 49 m x 16 m barns of arch-rib construction. A heated, insulated core examination room, 8.5 m x 12 m, is provided in one building. Pallet loads of core boxes are delivered to the core examination room by propane powered forklift truck. Design and tendering for a fourth building at the Stellarton Industrial Park, of similar type and size, was completed during the fall of 1986 with construction expected to proceed sometime during 1987. Additional core examination space (12 m x 15 m) will be provided with second floor office space for core library staff.

Although all the locations have core examination benches and other facilities, only the Stellarton locations are in regular use. All locations were at full capacity at the end of 1986 with approximately 380 000 metres of core in storage. The majority of the core is stored on pallets, with the remainder on racks. Most core is not confidential and can be viewed by any visitor with prior notice. Requests to sample core are handled on an individual basis, and approval for sampling is normally restricted to core that has not been previously split. Previously split core cannot be resampled except under special circumstances, or unless the core has been designated by the department as surplus. All sample material not utilized during analytical procedures (i.e. coarse rejects and pulps) and all data resulting from samples taken must be returned to the core library to prevent unnecessary duplication of sampling. Core splitters, diamond saws, an ultraviolet light and a binocular microscope are available for visitors' use in the Stellarton facilities.

The Canada - Nova Scotia Mineral Development Agreement (CNSMDA) is providing $485 000 for Core Library Programs over a five year period (1984-1989). Nearly half of these funds are committed towards construction of the fourth building in Stellarton Industrial Park while the balance of the funds is committed to a program of

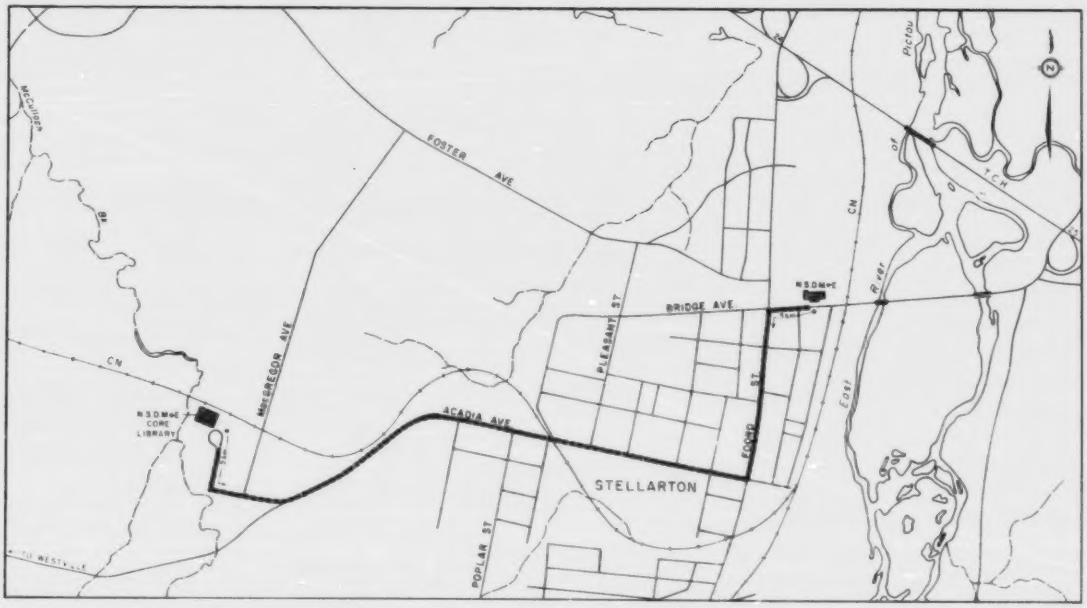

Figure 1. Location of drill core library, Stellarton.

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*Funded by the Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

core evaluation and disposal which was initiated in 1985. Two geologists (B. Palmer and D. Weir) were hired for the remaining duration of the Mineral Development Agreement to examine specific projects and areas from which large volumes of core have been obtained. This project will permit more efficient use of available space by selective disposal of surplus core following a process of detailed evaluation and report preparation. Recommendations will be circulated prior to disposal of any core. During 1986, evaluation of core from the Gays River area drilled by Getty Mines Limited was completed and evaluation of a large collection of core from the Walton barite-base metals-silver mine operated by Dresser Industries Incorporated was begun. No disposal of core has yet been undertaken.

A large volume of newly acquired core was received at the core library but the total was only 40% of the volume received in the previous year. For the 12 month period ending September 30, 1986, a total of approximately 26 628 metres (87,360 ft.) of additional core from 351 drillholes was received at the Stellarton core library from 13 companies or organizations responsible for 45 separate projects operating over the last 19 years (Table 1).

Although some of the core donated by industry is delivered by the donating company, the majority of the core originating from industry is collected by core library staff from industry storage locations. Companies wishing to donate core are advised that collection and transportation of core can usually be handled by core library staff subject to staff and equipment availability and scheduling, and subject to road access and weather considerations. Donations of up to approximately 1500 m can be retrieved by core library truck and trailer, while larger loads (up to 4500 - 6000 m) can be handled by the tractor trailer operated by the drilling section. The Nova Scotia Department of Mines and Energy welcomes donations of complete core sections, although space limitations require that such donations be subject to selective acceptance.

During 1986 approximately 12 storage or drill sites (excluding NSDME drill sites) were visited for the purpose of retrieving drill core. Core handling was in many cases facilitated by temporary staff (including students) seasonally hired under the CNSMDA or under the Provincial Summer Employment Program.

The total contents of the four storage locations is now estimated at 379 141 m (1,243,900 ft.) of core from 4615 holes drilled since 1945. This total consists of 90 325 m (296,352 ft.) from 845 holes drilled for the Department, and 288 816 m (947,559 ft.) from 3771 holes drilled by the mineral exploration industry and other organizations.

A preliminary detailed catalogue is available for consultation in the Stellarton office. None of the facilities is staffed on a full-time basis. Anyone wishing to examine core is advised to contact John McMullin, Jim Langille or Dennis Murphy at (902) 752-8429 or 752-4842 at least one day in advance of visiting the core library.

Table 1. Drill Core Acquisitions at Nova Scotia Department of Mines and Energy Core Library, October 18, 1985 to September 30, 1986

Company or Group	Location of Drilling	Year of Drilling	No. of Holes	Total Metres
Acadia Mineral Ventures Limited (SCOMINEX)	Miller Lake, Guysborough County	1984	10	532
Bear Pass Resources Corporation	Pleasant River Barrens, Lunenburg County	1985/86	20	961
Canada Cement Lafarge Limited	Brookfield, Colchester County	1984	9	284
Canada Cement Larfarge Limited	Admiral Rock, Hants County	1984	2	30
Canada Cement Lafarge Limited	Penny Mountain, Colchester County	1984/85	16	650
Canada Cement Lafarge Limited	Brookfield, Colchester County	1985	5	98
Canada Cement Lafarge Limited	East Mountain, Colchester County	1985	5	68
Chapman Brothers	Pugwash, Cumberland County	1986	21	286
Domtar Chemicals Limited	Nappan, Cumberland County	*	2	1 087

(continued)

Table 1. (continued)

Company or Group	Location of Drilling	Year of Drilling	No. of Holes	Total Metres
Domtar Chemicals Limited	Seaview, Richmond County	1968	1	653
Esso Minerals Canada	Gays River, Halifax County	1979/82	68	2 601
Geological Survey of Canada/ Nova Scotia Department of Mines and Energy	Beech Hill (Lake Charlotte), Halifax County	1986	1	66
Imperial Oil Limited	Mount Thom, Colchester County	1970/71	48	3 318
Imperial Oil Limited	Gordon Summit, Pictou County	1972	1	103
Imperial Oil Limited	McLellans Brook, Pictou County	1978	1	65
Imperial Oil Limited	Rutherford Brook, Colchester County	1978	2	27
Imperial Oil Limited	Brookfield, Colchester County	1978*	2	106
Imperial Oil Limited	*	*	1	25
Inco Limited (SCOMINEX)	Goldenville, Guysborough County	1985	8	2 500*
Inco Limited (SCOMINEX)	Molega, Queens County	1985	3	266
Inco Limited (SCOMINEX)	Molega, Queens County	1986	8	678
M.E.X. Explorations Limited*	Walton, Hants County	1983	10	1 339
M.E.X. Explorations Limited*	Londonderry, Colchester County	*	2	515
M.E.X. Explorations Limited*	Lower Burlington, Hants County	1984	1	40*
M.E.X. Explorations Limited*	Five Islands, Colchester County	*	1	20
M.E.X. Explorations Limited*	*	*	3	320
Nolan, Davis & Associates	Point Edward Cape Breton County	1983	20	39
Nolan, Davis & Associates	Halifax Airport Halifax County	1984	14	71
Noranda Exploration Company Limited	Orangedale, Inverness County	1980/81	4	2 015
Noranda Exploration Company Limited	Estmere, Inverness County	1981	1	516
Noranda Exploration Company Limited	Kempt Road, Richmond County	1981	1	333

(continued)

Table 1. (continued)

Company or Group	Location of Drilling	Year of Drilling	No. of Holes	Total Metres
Nova Scotia Department of Mines and Energy	Dean and Chapter Lake, Lunenburg County	1985	3	639
Nova Scotia Department of Mines and Energy	Riverside Corner, Hants County	1985/86	1	1 007
Nova Scotia Department of Mines and Energy	Sawmill Brook, Pictou County	1986	5	161
Nova Scotia Department of Mines and Energy	Eight Mile Brook, Pictou County	1986	5	151
Nova Scotia Department of Mines and Energy	Caribou Road, Pictou County	1986	3	133
Nova Scotia Department of Mines and Energy	Frasers Mountain, Pictou County	1986	1	137
Nova Scotia Department of Mines and Energy	Chance Harbour, Pictou County	1986	1	821
Nova Scotia Department of Mines and Energy	The Falls, Colchester County	1986	1	768
Nova Scotia Department of Mines and Energy	Amherst, Cumberland County	1986	3	101
Nova Scotia Department of Mines and Energy	Graham River, Inverness County	1986	1	4
Nova Scotia Department of Mines and Energy	Salmon River (Yava Mine), Cape Breton County	1986	12	498
Nova Scotia Department of Mines and Energy	Morley Road, Meadows Road, Cape Breton County	1986	8	459
Nova Scotia Department of Mines and Energy	Sissiboo Road, Digby County	1986	1	528
Pan East Resources Incorporated	Fifteen Mile Stream, Halifax County	1985	15	1 609
	Total		351	26 628*
	(Industry		305	21 155*)
	(Government		46	5 473)

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*subject to verification

INDUSTRIAL MINERALS*

J. H. Fowler

MINERAL RESOURCE PROJECTS - 1986

Six industrial mineral resource evaluation projects are being carried out by the Mineral Development Division under the Canada - Nova Scotia Mineral Development Agreement. The design and terms of reference for the commodity studies and mineral technology programs were developed by the Nova Scotia Department of Mines and Energy (NSDME), and Energy, Mines and Resources Canada (EMR). Mineral Policy Sector of EMR is the lead agency responsible for market studies and Canmet of EMR assumes a similar role with respect to mineral technology programs.

The objective of the resource studies is to create an awareness of the Province's industrial mineral resources and to promote resource development and production diversification. Programs underway include (1) a project to identify and promote the development of the building stone resources of the Province, (2) a program to document the gypsum and anhydrite resources of Nova Scotia, (3) an aggregate resource mapping project in selected regions of the Province, (4) a program to evaluate provincial diatomite resources, (5) a filler and extender market and resource evaluation study and (6) an evaluation and information database on many lesser known industrial minerals found in Nova Scotia. Each of these projects is described in more detail by the project leaders.

MARKET STUDIES - 1986

The following market studies are now available as Open File Reports (OFR) from the Nova Scotia Department of Mines and Energy:

1. **The Gypsum Industry in Nova Scotia, Present Status and Future Prospects,** NSDME OFR 752.

This report was prepared by the Centre for Resource Studies, Queens University. The report describes the current status of the gypsum industry in Nova Scotia and identifies future employment and resource generating opportunities.

2. **Study of Markets for Aggregate Materials Accessible from Nova Scotia and New Brunswick,** NSDME OFR 86-010.

This report was prepared by ADI Limited and describes the current market for aggregates accessible from New Brunswick and Nova Scotia. The report also provides a forecast of market potential to the year 2005 and an identification of other relevant factors which could influence aggregate marketing.

3. **A Study of Industrial Minerals Used in Oil and Gas Exploration on the Eastern Canadian Offshore,** NSDME OFR 86-012.

This report was prepared by Jacques, Whitford and Associates and Cleland, Sunsmuir Consulting Limited to examine the use of industrial minerals within the Oil and Gas Exploration Industry on the east coast of Canada.

4. **Study of Markets for Silica and Silica Sands Accessible from Nova Scotia and New Brunswick,** NSDME OFR 86-013.

This report was prepared by ADI Limited to determine and quantify markets for silica and silica sands reasonably accessible from Nova Scotia and New Brunswick.

MINERAL TECHNOLOGY STUDIES - 1986

The following studies are currently in progress:

1. **Development of Engineering Data on Nova Scotia Fly Ash.** This study will provide comprehensive engineering data to identify more extensive uses of fly ash in the concrete industry. The contract for this study was awarded to L. E. Shaw Limited.

2. **Evaluation of the Pine Brook, Richmond County, Barite Deposit.** The study includes grinding and gravity separation tests on a bulk sample of barite ore from the Pine Brook deposit.

INDUSTRIAL MINERAL COMMODITIES MAP

MAP 85-1

A new Industrial Mineral Commodities Map for the Province of Nova Scotia (NSDME Map 85-1), compiled by J. H. Fowler, was released in 1986. This map locates industrial mineral deposits and occurrences of the Province, and also shows the location of present and past industrial mineral production operations.

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*Funded by Nova Scotia Department of Mines and Energy, and Mineral Policy Sector and Canmet of Energy, Mines and Resources Canada under the Canada - Nova Scotia Mineral Development Agreement

GYPSUM/ANHYDRITE PROJECT*

G. C. Adams

The Gypsum/Anhydrite Project was initiated in June 1985 through the Canada - Nova Scotia Mineral Development Agreement to develop an inventory of the gypsum and anhydrite resources of the Province. Three goals have been established for the project. The primary goal is to produce a comprehensive mineral inventory. The second is to increase and enhance relations between the Nova Scotia Department of Mines and Energy and present producers in the Province. The third goal is to initiate and encourage development of alternative utilization of provincial gypsum and anhydrite resources.

During the 1986 field season gypsum occurrences in Cape Breton, Richmond and Inverness Counties on Cape Breton Island, and in Hants County on the mainland were mapped and sampled (Fig. 1). Over 200 samples were taken from as many occurrences and these samples have been analyzed for gypsum, anhydrite and salt content. Additional analysis is planned pending budgetary approval. Results are presently being compiled on 1:250 000 base maps and areas of significance will be studied in detail using existing drillhole information where available.

In addition, a small drilling program comprising 8 drillholes totalling 647 m was undertaken to investigate the potential for extractable reserves of gypsum and anhydrite in the Sydney Basin. This program was proposed on the basis of drilling results by Morton Chemicals in 1960 and 1961, and Nova Scotia Department of Mines and Energy in 1984. These results indicated that gently dipping sulphate beds appear to be continuous both laterally and down dip in the Meadows Road Formation of the Windsor Group in the Meadows Road area (Fig. 2). Results, although still preliminary, reveal good reserves of both gypsum and anhydrite amenable to underground mining within the industrial Cape Breton area.

The development of a more open relationship between gypsum companies and the Department is an ongoing process. To date, two of the Province's five major producers have allowed access to geological and technical information on deposits which they own in fee simple or for which they hold gypsum rights. Assistance, when requested, has been provided to all gypsum producers.

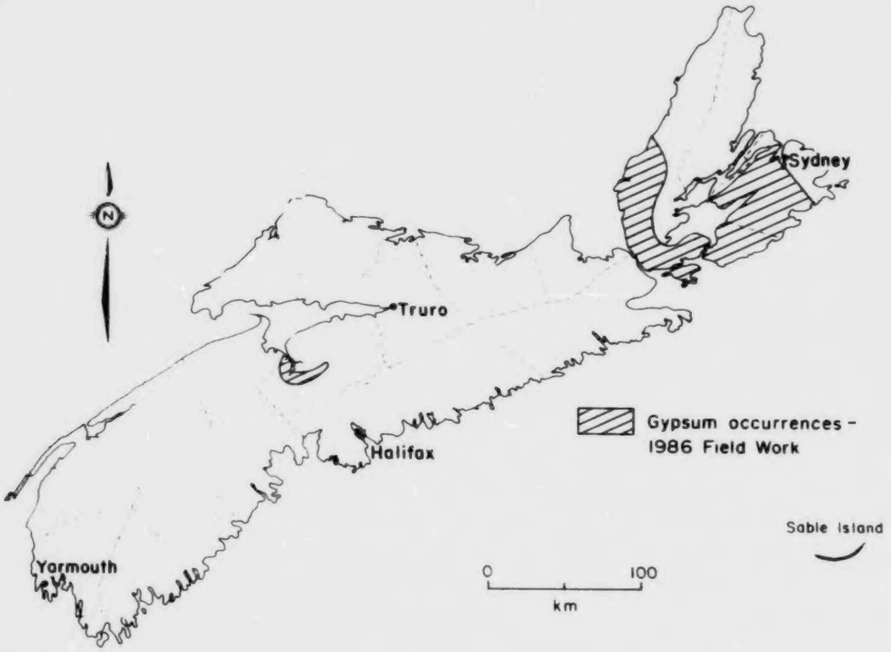

Figure 1. Gypsum/anhydrite project fieldwork.

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

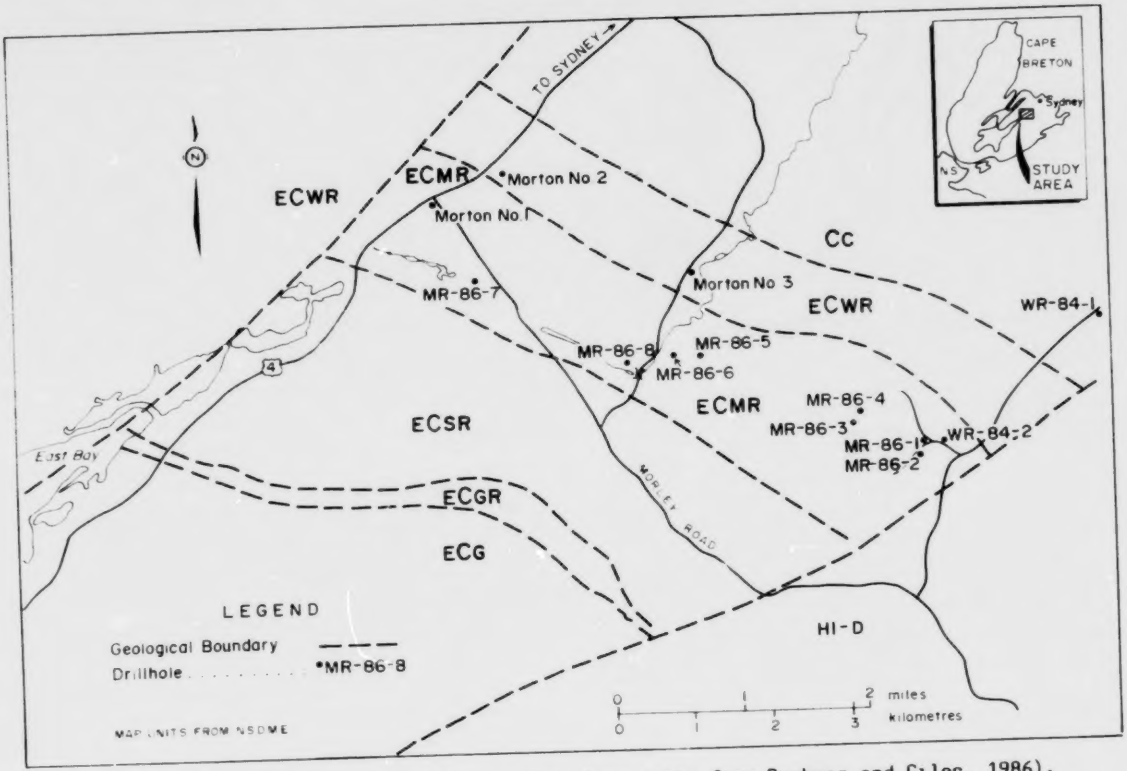
TO SYDNEY
N
ECWR
ECMR
Morton No 2
Morton No 1
CC
Morton No 3
ECWR
WR-84-1
MR-86-7
MR-86-8
MR-86-5
MR-86-6
4
ECMR
MR-86-4
MR-86-3
MR-86-1
WR-84-2
MR-86-2
ECSR
East Bay
ECGR
MORLEY ROAD
ECG
HI-D
LEGEND
Geological Boundary
Drillhole .... •MR-86-8
MAP UNITS FROM NSDME
0 1 2 miles
0 1 2 3 kilometres
CAPE BRETON
Sydney
NS
STUDY AREA

Figure 2. Meadows Road Drilling Program (map units from Boehner and Giles, 1986).

So far, several topics have been investigated under the heading of alternative utilization of provincial gypsum and anhydrite resources. A study on the market potential for agricultural gypsum by P. Luke of Nova Scotia Department of Mines and Energy was completed in 1986 and is available as NSDME OFR 86-039. Ongoing studies at McGill University into coal mine roadside packing systems including anhydrite may help to encourage its use here in Nova Scotia and elsewhere in North America, as it has been used in West Germany for more than 15 years. Other investigations are currently underway and results will be reported later.

REFERENCE

Boehner, R. C. and Giles, P. S.
1986: Geological map of the Sydney Basin, Cape Breton Island, Nova Scotia; Nova Scotia Department of Mines and Energy, Map 86-1, scale 1:50 000.

AGGREGATE RESOURCES PROJECT*

G. Prime

The aggregate industry of Nova Scotia ranks as the second most valuable mining activity in the Province in terms of product value and employment. As a result of its importance, there has been a substantial effort on the part of the Province to provide a comprehensive evaluation of these resources (e.g. Fowler, 1981; Fowler and Dickie, 1977; 1978; Wright, 1981; 1982; in press). The Aggregate Resources Project represents a continuation of this task.

There are three main objectives to the project: (1) to evaluate the aggregate resources of northern Nova Scotia, (2) to identify quarriable aggregate sites in proximity to the Halifax-Dartmouth area and (3) to investigate the potential of establishing coastal aggregate operations for export markets. Reports will be produced at the end of the program in two years.

Work in the first year is being focused on northern Nova Scotia where the granular aggregate in Cumberland and Colchester Counties is being examined (Fig. 1). The goals this year are to document the occurrences of sand and gravel, assess their quality and identify new reserves. This information will be compiled in a report and map (scale 1:125 000).

Surficial mapping of the two counties began in July 1986 and will continue into the 1987 field season. This procedure involves the examination of all exposures and detailed description of all pits. Aerial photographs and diamond-drill logs are being used to help delineate the deposits with more accuracy. Based on the mapping results, a selective sampling program will be performed. Sample analyses will determine size gradation, soundness, abrasion, petrograhic composition and organic content. If time permits, selected areas will be examined in more detail using seismic profiling.

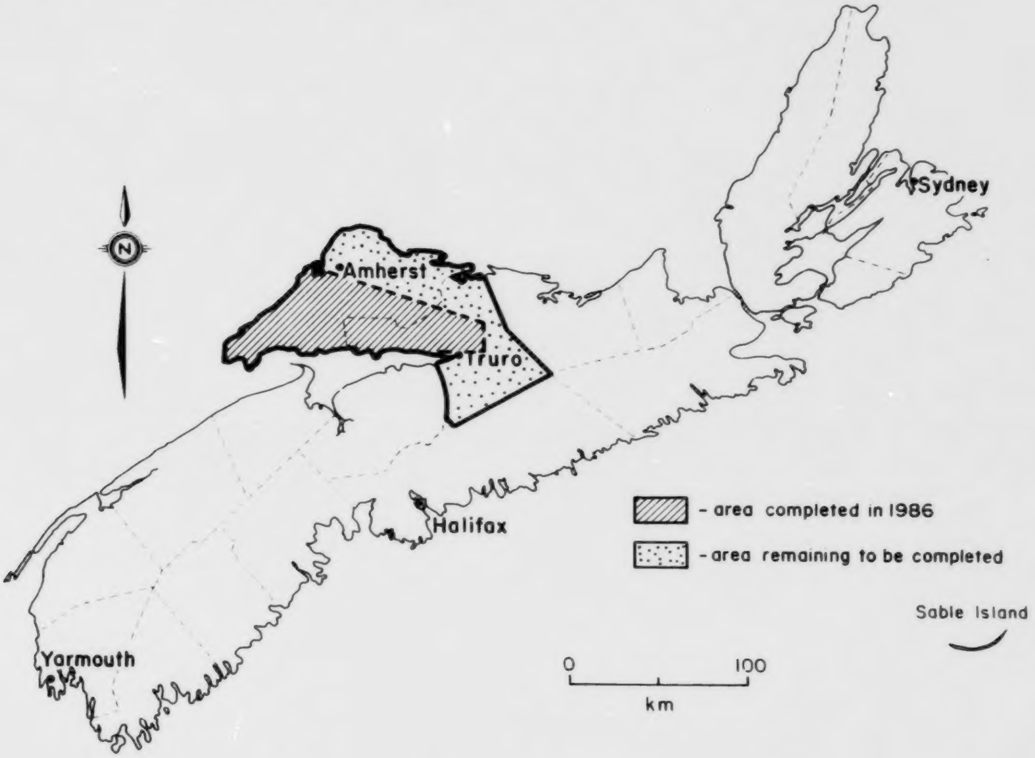
N
Sydney
Amherst
Truro
Halifax
Yarmouth
▨ - area completed in 1986
░ - area remaining to be completed
Sable Island
0
100
km

Figure 1. Location of study area.

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*Funded by the Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

With the assistance of a summer student, B. Cochrane, approximately 50% of the necessary field mapping was accomplished during the past field season (Fig. 1). Preliminary results indicate that aggregate deposits in the area are primarily glaciofluvial, ice contact and marginal marine in origin. The quality of the deposits appears to improve near or on the Cobequid Highlands, reflecting a greater influence from this source area.

A potential alternative source for aggregate in the form of mechanically and chemically weathered conglomerate is also being examined. Currently being excavated for road fill, this material is of interest because of its semi-consolidated state, relative abundance, thickness (1-6 m), and high quality petrograhic composition. As a result, qualitative testing will be conducted on some of the more promising deposits.

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Fowler, J. H.
1981: Aggregate Resources in Nova Scotia; Canadian Institute of Mining and Metallurgy Bulletin, v. 75, no. 844, p. 100-102.

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1977: Sand and Gravel Resources of Pictou County; Nova Scotia Department of Mines, Paper 77-6, 42 p.

1978: Sand and Gravel Occurrence Maps; Nova Scotia Department of Mines, Open File Report 378.

Wright, W. J.
1981: Aggregate resources of Cape Breton Island; _in_ Mineral Rnsources Division, Report of Activities, 1981, ed. K. A. Mills; Nova Scotia Department of Mines and Energy, Report 82-1, p. 23-24.

1982: Aggregate resources of southwestern Nova Scotia; _in_ Mines and Minerals Branch, Report of Activities 1982, ed. K. A. Mills; Nova Scotia Department of Mines and Energy, Report 83-1, p. 35.

in press: Aggregate Resources of Cape Breton Island; Nova Scotia Department of Mines and Energy, Paper 85-1.

FILLER AND EXTENDER PROJECT*

P. Luke

Mineral fillers are generally inert, finely ground mineral substances that are incorporated into the manufacturing of various products. They primarily serve to reduce the consumption of more expensive raw materials such as plastic resin or rubber. In the case of extenders they enhance the usefulness of the final products by introducing some new property or properties.

This program to identify users of mineral fillers and extenders in the Atlantic provinces was initiated in July 1986. Companies manufacturing paint, paper, plastics, rubber products and carpets that use mineral fillers such as limestone, talc, kaolin or baryte have been identified (Fig. 1) and contacted to determine quantity and quality of the fillers being used. Results of this market study will be compiled into a Departmental report.

Detailed studies on several known industrial mineral occurrences in Nova Scotia with potential for filler use will follow the market analysis.

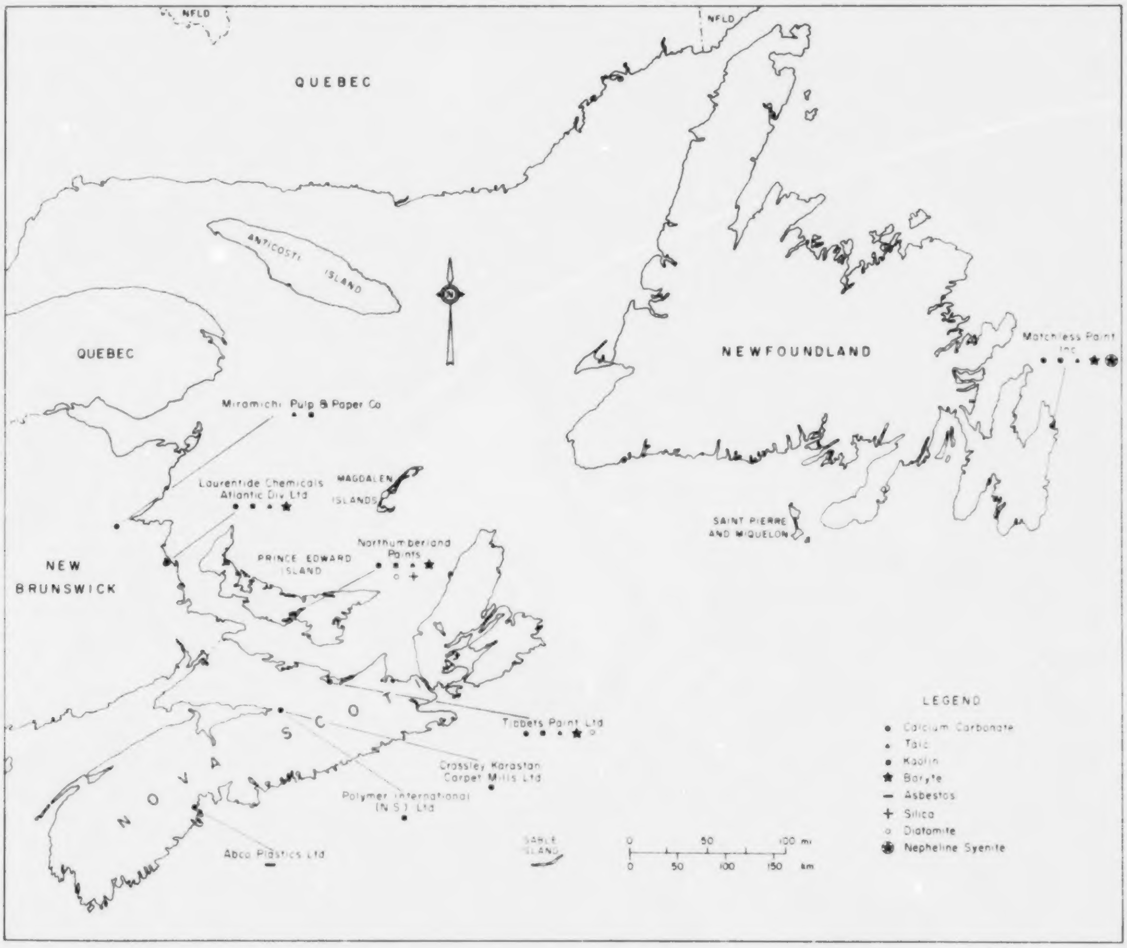
NFLD
NFLD
QUEBEC
ANTICOSTI ISLAND
QUEBEC
NEWFOUNDLAND
Matchless Point Inc
Miramichi Pulp & Paper Co
Laurentide Chemicals Atlantic Div Ltd
MAGDALEN ISLANDS
SAINT PIERRE AND MIQUELON
NEW BRUNSWICK
PRINCE EDWARD ISLAND
Northumberland Paints
NOVA SCOTIA
Tibbets Point Ltd
Crossley Karastan Carpet Mills Ltd
Polymer International (N.S.) Ltd
Abco Plastics Ltd
SABLE ISLAND
0 50 100 mi
0 50 100 150 km
LEGEND
Calcium Carbonate
Talc
Kaolin
Baryte
Asbestos
Silica
Diatomite
Nepheline Syenite

Figure 1. Major filler and extender mineral users in the Atlantic region.

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*Funded by the Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

DIATOMACEOUS EARTH PROJECT*

A. R. Anderson

INTRODUCTION

Diatomaceous earth or "diatomite" is a siliceous sedimentary material commonly found in lakes and bogs in the upper reaches of many watersheds throughout Nova Scotia. This commodity is formed by the accumulation of the skeletal remains or shells of tiny one celled plants known as diatoms. Diatomaceous earth is essentially composed of hydrous silica ($SiO_2.nH_2O$) and is characterized by low specific gravity, large surface area and high porosity, making it valuable as a filler and filter aid.

Although the vast majority of finished diatomite (545 000 tonnes) is used annually as a filter aid, 41 - 45 thousand tonnes of diatomite are used as a filler or extender in the paint, plastics and paper industries. Diatomaceous earth can also be used as an absorbent, chemical carrier, insulator and as an additive for Portland cement.

Diatomaceous earth was mined at several locations in Nova Scotia from 1928 to 1952. Roughly 11 800 tonnes of semiprocessed diatomite were produced from three sites at Little River, Digby County, and Oxford and New Annan in Colchester County. The product was used as a mild abrasive, in insulating firebrick and as a filler in rubber products. As markets changed and production of high quality, low cost diatomite and replacement fillers came on the market, production in Nova Scotia ceased. However, new uses and expanding markets now exist for diatomite.

PROGRAM ACTIVITIES 1986-1987

Literature research has identified 128 diatomite occurrences in Nova Scotia (Fig. 1) ranging from 5-10 cm to 3.5-4.5 m in thickness and as much as 20 - 30 hectares in area (most less than 10 hectares).

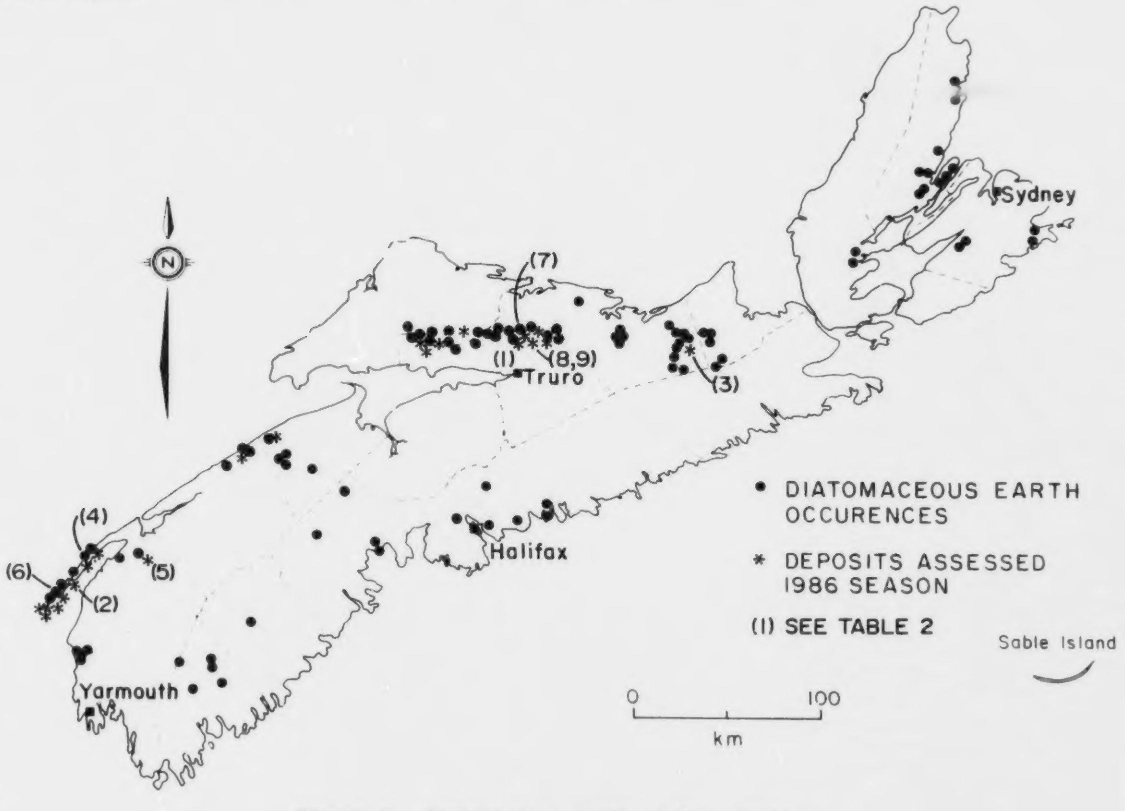

Figure 1. Diatomaceous earth in Nova Scotia.

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

Diatomaceous earth found in the lakes and bogs of Nova Scotia varied from a whitish-grey, dense, compacted, silt-like sediment to a dark grey-brown, somewhat amorphous, semi-gelatinous ooze. The latter was commonly found in peatlands and was generally uniform in texture, with underlying layers of denser, pale grey-brown diatomaceous earth. Variations in diatomaceous earth colour and texture were extreme in lakes. Dense, white-orange or green stained sediments, 10-50 cm thick, were commonly found in shallow water (<2 m), while in deeper water softer, grey diatomaceous earth occurred in layers up to 3-4 m thick.

Twenty-one deposits with the most potential were sampled during the past field season, employing 120 sample sites and providing 240 samples of 1-2 kg of diatomaceous sediment (Table 1). Samples were collected using a 50 cm MacAulay auger and a 1 m Hiller auger, which also provided additional deposit information.

Mapping and resource calculation in the most significant deposits assessed this past year indicate 1.71 million m^3 of diatomaceous sediment (Table 2). An additional 1.6 million m^3 of diatomaceous earth are estimated to occur in a larger deposit on the Digby Neck, however this deposit has been listed or proposed as a Biological Reserve.

A number of the sites investigated did not reveal any significant occurrence of diatomaceous earth, including the peat deposits on Brier Island and the old Fundy Cranberry Bog near Margretsville. Previously mined sites at Tatamagouche Silica Lake (Rhude Pond) and Bass River Silica Lake have virtually been mined out. Only minor occurrences were noted at these locations, however of note in the northern end of Bass River Silica Lake, about one hectare of a grey soft diatomaceous sediment 1-2 m thick was found among the old silica mine workings.

The largest and most promising deposits are noted in Table 2. The Factory Bog, Digby County, (previously mined for its resources); Brora Lake, Pictou County; and Harris Lake, Digby County are the largest accumulations outside the Central Grove deposit and would be the most likely prospects in the Province. However, it should be

Table 1. Diatomacous Earth Samples, 1986

Location	Sites	Samples
Lake Bottom Sediments		
Brora Lake, Pictou County	11	51
Harris Lake, Digby County	5	9
Factory Bog, Digby County	14	60
Silica Lake, Colchester County	6	14
Clear Lake, Colchester County	11	25
Trout Lake, Colchester County	12	32
Lily Pond, Colchester County	3	13
Bass River Silica Lake, Colchester County	3	3
Isaacs Lake, Cumberland County	4	2
Peatland Bottom Samples		
Stillwater Bog - No. 3, Colchester County	1	3
Stillwater Bog, Colchester County	1	8
Stillwater Bog - No. 2, Colchester County	1	7
Bear River, Digby County	9	11
Central Grove, Digby County	7	22
Bog No. 5, Digby County	2	0
Bog No. 6, Digby County	1	4
Bog No. 9, Digby County	3	3
Small Property Bog, Digby County	3	3
Brier Island - No. 1, Digby County	4	0
Brier Island - No. 2, Digby County	4	0
Fundy Cranberry Bog, Annapolis County	3	0

Table 2. Indicated Diatomaceous Earth Resources

Deposit	Area (ha)	Volume (m^3)
1. Trout Lake	15	192 150
2. Harris Lake	22	346 200
3. Brora lake	22	329 500
4. Factory Bog	23	381 550
5. Big Bend Deadwaters	11	270 650
6. Central Grove	45	1 623 160 (IBP site)
7. Clear Lake	3	50 700
8. Stillwater Bog #1	2	52 370
9. Stillwater Bog #2	2	57 600
		3 303 880

noted that the Harris Lake deposit is under a few metres of peat which is itself under about one metre of water.

All samples collected are currently being analyzed to determine the quality of the diatomite in the surveyed deposits. Whole-sediment analysis, bulk density, organic content, moisture content, specific gravity and particle-size distribution are being determined on all of the samples collected. A subset of the most significant samples will be tested to determine hardness, oil absorbency, brightness, acid resistivity and abrasiveness. In addition, field assessment records will be correlated with Munsell Soil Color Indices and the whole-sediment analyses to provide a method that will allow field assessment of the numerous occurrences in the Province.

BUILDING STONE PROJECT*

G. B. Dickie

INTRODUCTION**

The Building Stone Project was initiated in September 1985 as a five year Canada - Nova Scotia Mineral Development Agreement program to identify, evaluate and prepare technical and promotional material on the stone resources of Nova Scotia for the purpose of encouraging the orderly development of these resources. The program will be carried out in a number of phases, beginning with an initial evaluation of past-producing quarries and followed by detailed studies, including diamond-drilling and quality testing on the most promising deposits. The identification of new building stone deposits will be a significant part of the program.

Stone has been used for building construction in Nova Scotia since the late 17th and early 18th centuries. The first stone used was probably imported ballast, but after the early 1800s a flourishing domestic industry provided mainly sandstone for both local and export markets. As many as 75 sandstone quarries and 10 granite quarries (Fig. 1) produced stone in the mid 1800s for a total recorded production of over 1.1 million tons in the period 1873-1973 (Fig. 2). Sandstone accounted for 90% of the total, granite 4.9% and grindstone 3.1%. Of the total sandstone production, the Wallace quarry contributed 94.8% (Figs. 3 a, b).

1986 FIELD PROGRAM

SANDSTONE

Over 75 quarries periodically produced sandstone in northern Nova Scotia over the last 150 years. The 1986 field program completed an initial reconnaissance of most of the quarry sites. Many of the quarries were overgrown, eroded from river banks or caved in. Several quarries were located which were significant past producers, and four of these were selected for diamond-drill programs. This work has identified very significant resources of building stone in four locations.

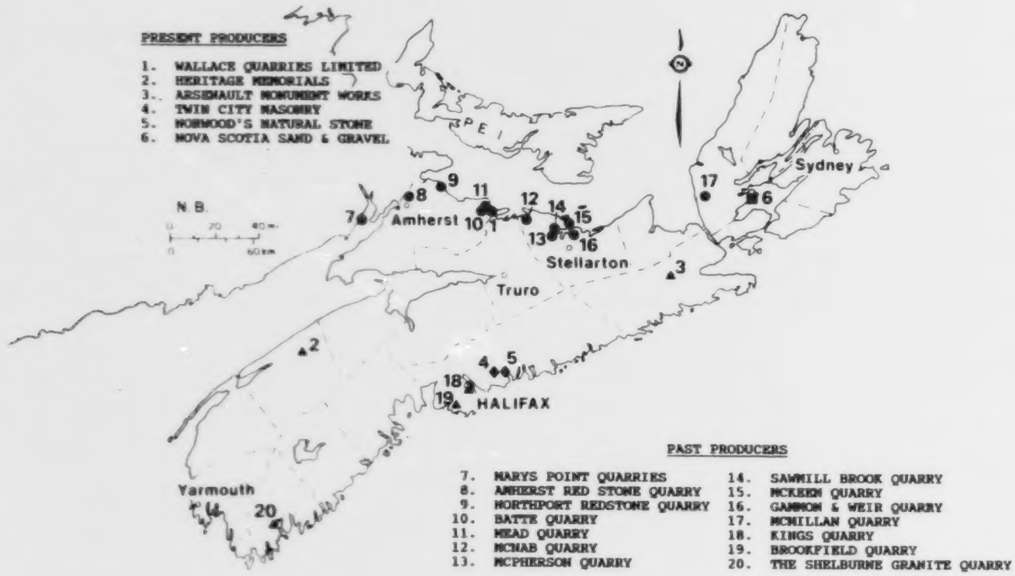
PRESENT PRODUCERS
1. WALLACE QUARRIES LIMITED
2. HERITAGE MEMORIALS
3. ARSENAULT MONUMENT WORKS
4. TWIN CITY MASONRY
5. NORWOOD'S NATURAL STONE
6. NOVA SCOTIA SAND & GRAVEL
P E I
N. B.
0 20 40 mi
0 60 km
N
Sydney
Amherst
Stellarton
Truro
HALIFAX
Yarmouth
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
PAST PRODUCERS
7. MARYS POINT QUARRIES
8. AMHERST RED STONE QUARRY
9. NORTHPORT REDSTONE QUARRY
10. BATTE QUARRY
11. MEAD QUARRY
12. MCNAB QUARRY
13. MCPHERSON QUARRY
14. SAWMILL BROOK QUARRY
15. MCKEEN QUARRY
16. GAMMON & WEIR QUARRY
17. MCMILLAN QUARRY
18. KINGS QUARRY
19. BROOKFIELD QUARRY
20. THE SHELBURNE GRANITE QUARRY

Figure 1. Present and major past stone quarries. Legend: solid triangle-granite; solid circle-sandstone; solid square-marble; solid diamond-other.

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*Funded by the Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

**All measurements are cited in Imperial measure in this paper to conform to the usage of the building stone industry.

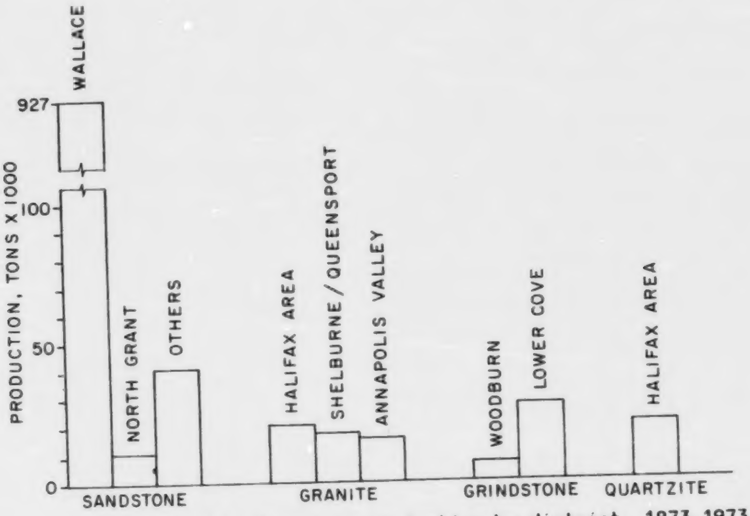

Figure 2. Nova Scotia freestone production by district, 1873-1973.

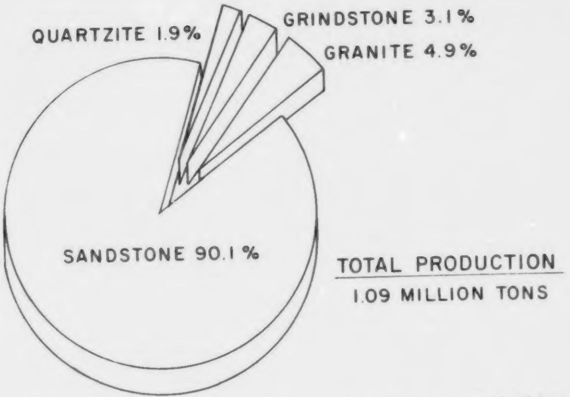

Figure 3a. Nova Scotia freestone production 1873-1973.

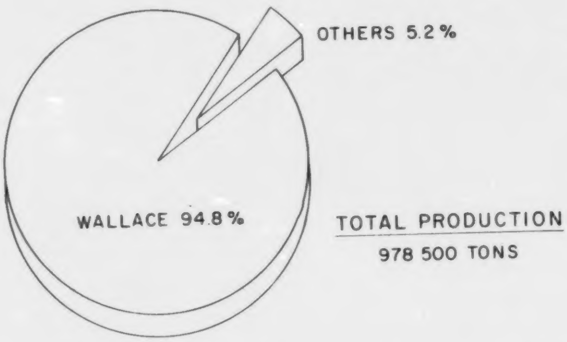

Figure 3b. Nova Scotia sandstone production 1873-1973.

1. Wallace Quarry

The Wallace quarry has produced three colours of stone in the past. The greatest volume of stone produced was a medium to dark olive-green, fine- to medium-grained massive sandstone of possible Late Carboniferous age. The average thickness of the quarried unit was 40 feet. It overlies a fine- to medium-grained blue-grey sandstone with an average thickness of about 10 feet. A light olive-green sandstone was also produced from small pockets on the northwestern and western side of the quarry. At present very little sandstone is available in the quarry without removing up to 20 feet of overburden and shale. Furthermore, there was no drill information outlining additional reserves of stone for future quarrying. Consequently, the Nova Scotia Department of Mines and Energy carried out a diamond-drill program consisting of 8 holes totalling 1045 feet on the east side of the quarry (Fig. 4) to locate additional reserves of sandstone.

Between 19 and 27 feet of massive fine- to medium-grained olive sandstone was intersected in holes Wal-86-4 and -5 beneath 38 feet of overburden, sandstone and shale. Two units of blue-grey sandstone were intersected below the olive sandstone and a thin shale unit. Approximately 26,000 tons of green sandstone and 84,000 tons of blue-grey sandstone were outlined in this program with the resource open to north and east.

2. Amherst Quarry

This is one of the oldest quarries in northern Nova Scotia and the pinkish-red stone raised for building stone from this location is probably as well known as the olive-green Wallace stone. The quarry is about 100 feet deep, 300 feet in diameter and presently filled with water.

Three drillholes were collared on the west side of the quarry (Fig. 5) totalling 371 feet. All holes intersected 60-72 feet of red, fine- to medium-grained massive sandstone of the Pictou Group. The stone was overlain by 12-14 feet of

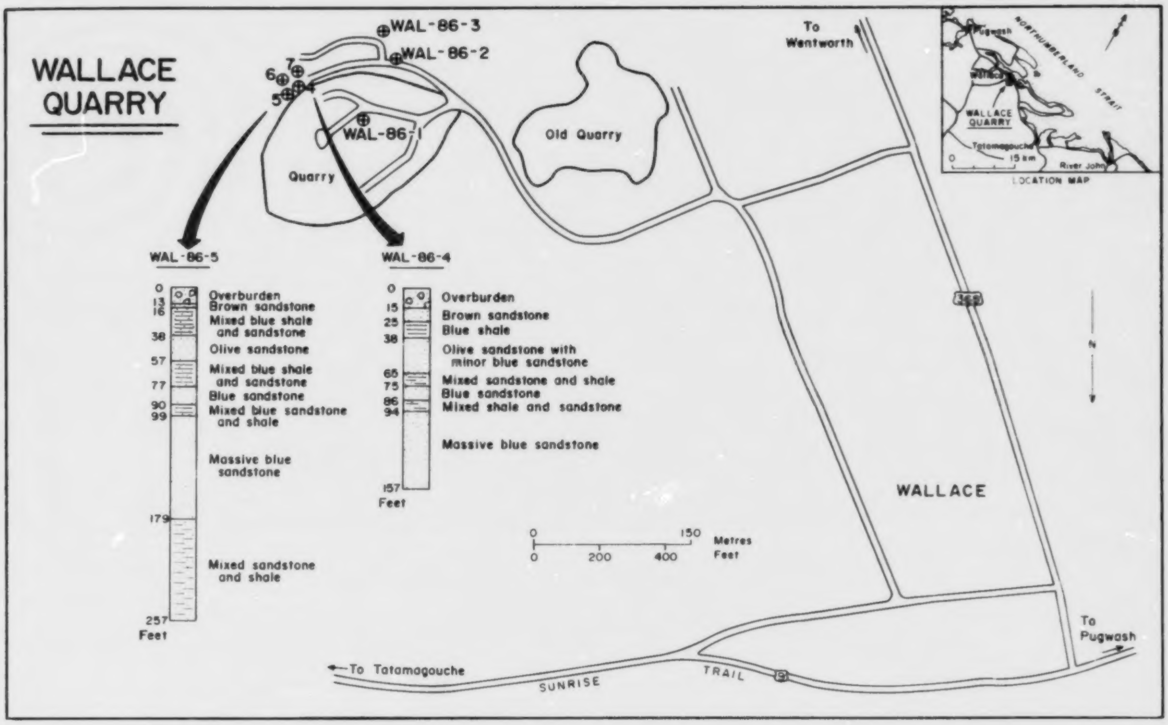
WALLACE QUARRY
WAL-86-3
WAL-86-2
WAL-86-1
7
6
5
4
Quarry
Old Quarry
To Wentworth
Pugwash
NORTHUMBERLAND STRAIT
Wallace
WALLACE QUARRY
Tatamagouche
0
15 km
River John
LOCATION MAP
368
N
WALLACE
WAL-86-5
0
13
16
38
57
77
90
99
179
257
Feet
Overburden
Brown sandstone
Mixed blue shale and sandstone
Olive sandstone
Mixed blue shale and sandstone
Blue sandstone
Mixed blue sandstone and shale
Massive blue sandstone
Mixed sandstone and shale
WAL-86-4
0
15
25
38
65
75
86
94
157
Feet
Overburden
Brown sandstone
Blue shale
Olive sandstone with minor blue sandstone
Mixed sandstone and shale
Blue sandstone
Mixed shale and sandstone
Massive blue sandstone
0
150
Metres
0
200
400
Feet
To Pugwash
To Tatamagouche
SUNRISE
TRAIL
6

Figure 4. Wallace Quarry diamond-drill hole locations and sections.

overburden and underlain by 38 feet of red siltstone and/or mudstone. This drilling has outlined 70,000 tons of sandstone and the resource is open in all directions.

3. Eight Mile Brook

A small quarry was operated by a gravestone manufacturer on Eight Mile Brook at the beginning of this century. Mr. McPherson exploited a fine grained, massive, light grey sandstone of the Riversdale Group exposed in the stream bed. A drill program consisting of 7 holes totalling 736 feet was carried out in April and June 1986. The goal of the program was to locate the grey sandstone horizon on the north bank of the brook on the level of the road to Stillman. Holes EMB-86-3, -4 and -5 intersected the grey sandstone at 17, 21 and 36 feet, respectively (Fig. 6). The grey stone varies in thickness from 21-47 feet and is overlain by 15-17 feet of overburden and minor amounts of brown sandstone. Hole EMB-86-7 intersected 15 feet of grey sandstone to the northeast along strike. A deposit of 66,000 tons of high quality grey sandstone was outlined by this program.

4. Sawmill Brook Quarry

This quarry produced a light olive-green to tan sandstone for the export market in the period between 1850 and 1870. Stone from this quarry was also used in a number of stone buildings in Pictou County and in buildings in the city of Halifax. In order to assess the quantity and quality of stone remaining, the quarry was pumped out and mapped and a diamond-drill program consisting of 6 holes totalling 631.5 feet was carried out between March and July, 1986.

The sandstone exposed in the quarry strikes northeast and dips 25° to the southeast. Two sandstone horizons were quarried, separated by 6 feet of shale for a total thickness of about 40 feet. Due to the dip of the sandstone, it was not exposed on top of the stream bank where the drilling was carried out. However, a red-brown, fine- to medium-grained sandstone was intersected in holes SMB-86-1, -4, -5 and -6. This stone may serve as a substitute for the Mary Point, New Brunswick, brown sandstone which was used in many Halifax buildings. Only the top 10-12 feet of the red-brown sandstone is suitable for Marys Point stone substitution and is presently under overburden varying in thickness from 10-16 feet in holes SMB-86-5 and -6 (Fig. 7). Approximately 10,000 tons of red-brown stone were outlined by this drill program.

GRANITE

Evaluation of Nova Scotia granite deposits on the southern mainland and Cape Breton Island has begun. Several old granite quarries have been mapped and sampled to determine their suitability for curbing stone, cladding and dimension stone. Deposits in the Terrance Bay area, Halifax County, may be very suitable for building stone. The best granite deposits will be diamond-drilled and comprehensive evaluation programs will be undertaken in 1987.

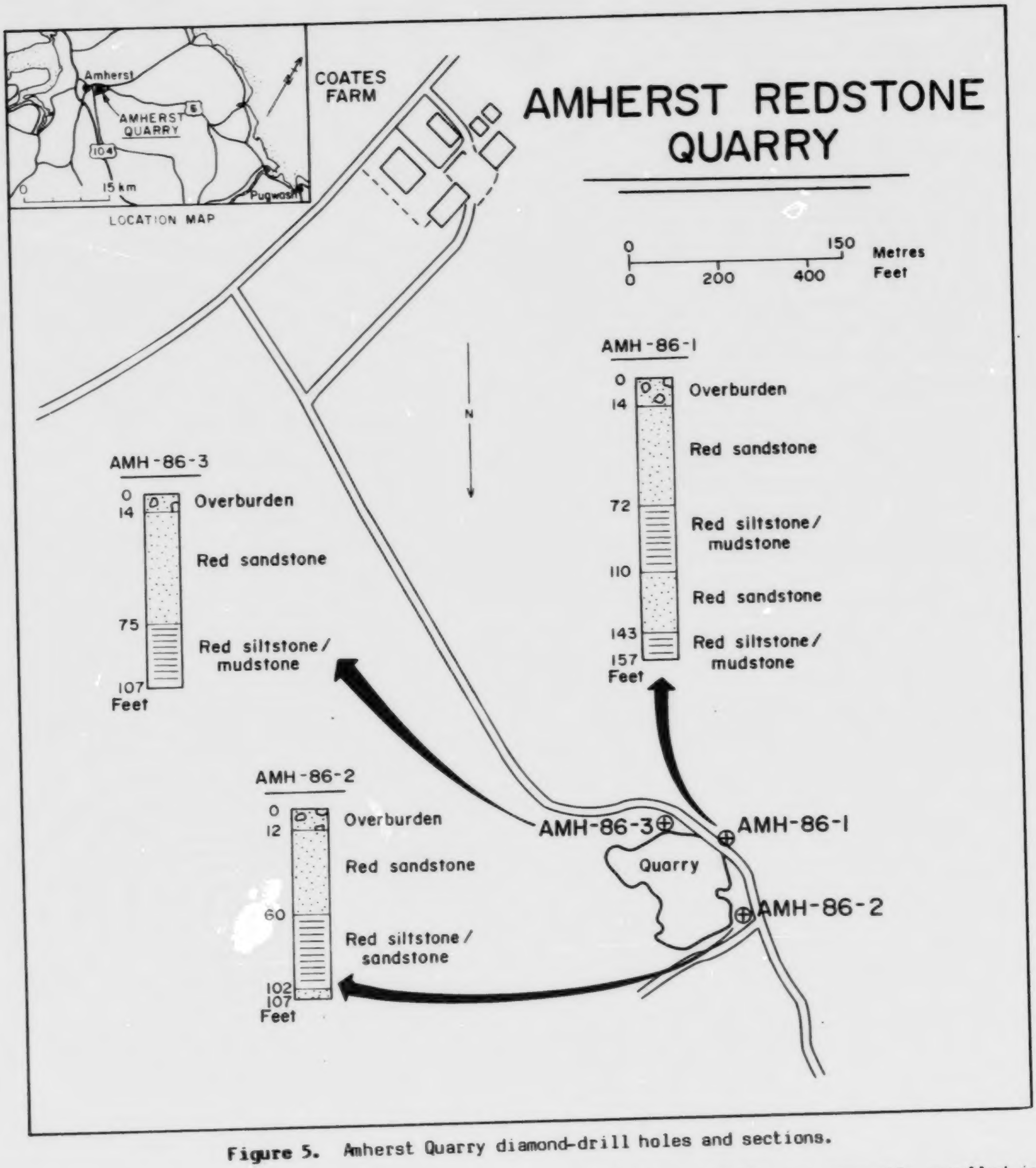
AMHERST REDSTONE QUARRY
COATES FARM
Amherst
AMHERST QUARRY
6
104
0
15 km
Pugwash
LOCATION MAP
0
150
Metres
0
200
400
Feet
N
AMH-86-1
0
14
72
110
143
157
Feet
Overburden
Red sandstone
Red siltstone/ mudstone
Red sandstone
Red siltstone/ mudstone
AMH-86-3
0
14
75
107
Feet
Overburden
Red sandstone
Red siltstone/ mudstone
AMH-86-2
0
12
60
102
107
Feet
Overburden
Red sandstone
Red siltstone/ sandstone
AMH-86-3
AMH-86-1
AMH-86-2
Quarry

Figure 5. Amherst Quarry diamond-drill holes and sections.

OTHER ACTIVITIES

A stone building inventory was begun by D. Wilkinson in 1986 to catalogue all stone buildings in Nova Scotia. Over 100 buildings, constructed either in part or totally of stone, have been examined. Over 60% of these are in the city of Halifax. The towns of Pictou, Amherst, Truro, New Glasgow and Sydney also have a number of stone buildings.

Twelve students are currently enrolled in a Stone Mason Apprentice Program in conjunction with the restoration of Province House. As part of the training program the Nova Scotia Department of Mines and Energy, through the Building Stone Project, is providing a lecture series and field trips on geology to the apprentices.

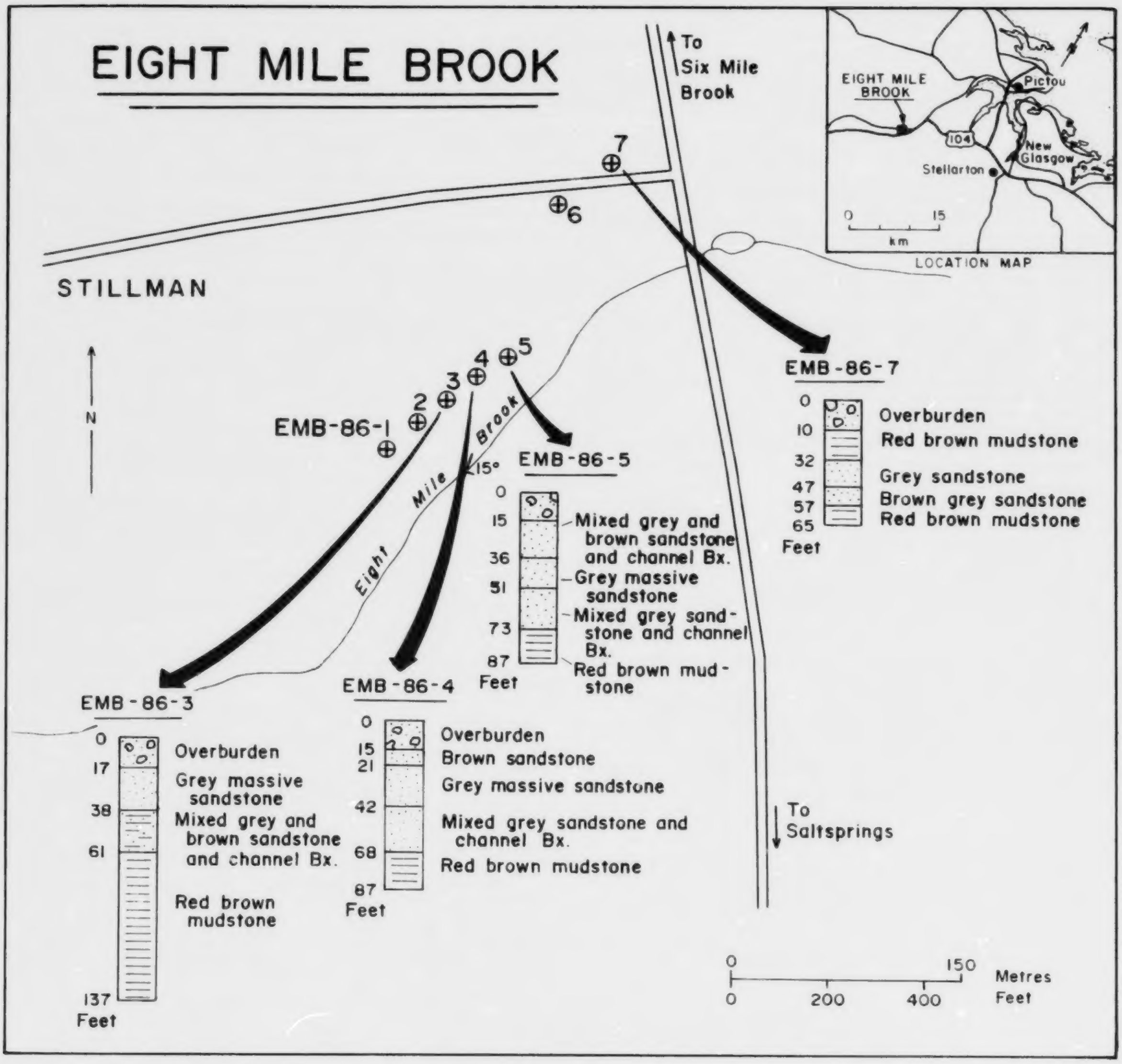
EIGHT MILE BROOK
To
Six Mile
Brook
EIGHT MILE
BROOK
Pictou
104
New
Glasgow
Stellarton
0
15
km
LOCATION MAP
7
6
STILLMAN
N
EMB-86-1
2
3
4
5
Eight Mile Brook
15°
EMB-86-7
0
10
32
47
57
65
Feet
Overburden
Red brown mudstone
Grey sandstone
Brown grey sandstone
Red brown mudstone
EMB-86-5
0
15
36
51
73
87
Feet
Mixed grey and brown sandstone and channel Bx.
Grey massive sandstone
Mixed grey sandstone and channel Bx.
Red brown mudstone
EMB-86-3
0
17
38
61
137
Feet
Overburden
Grey massive sandstone
Mixed grey and brown sandstone and channel Bx.
Red brown mudstone
EMB-86-4
0
15
21
42
68
87
Feet
Overburden
Brown sandstone
Grey massive sandstone
Mixed grey sandstone and channel Bx.
Red brown mudstone
To
Saltsprings
0
150
Metres
0
200
400
Feet

Figure 6. Eight Mile Brook diamond-drill hole locations and sections.

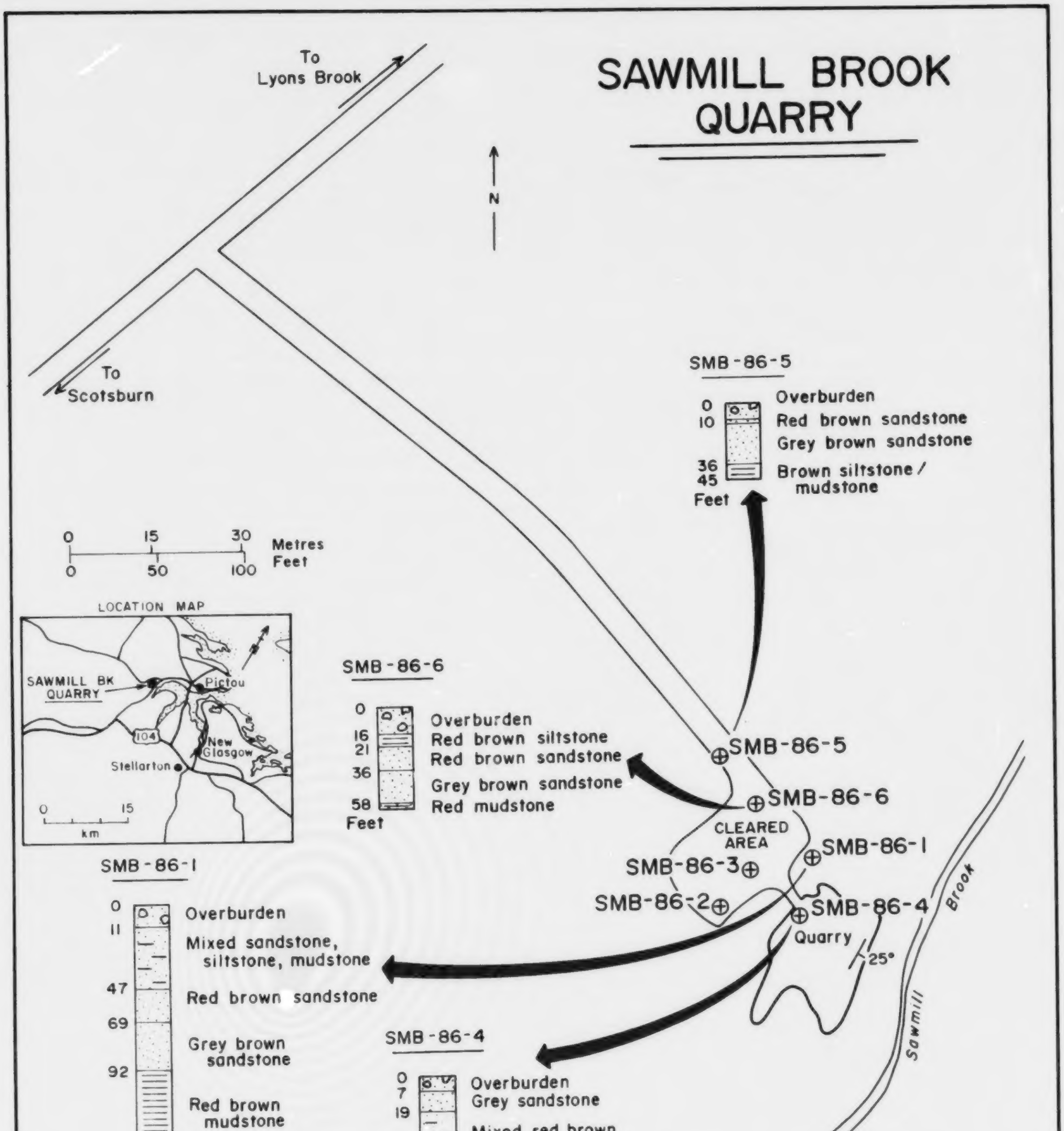
SAWMILL BROOK
QUARRY
To
Lyons Brook
To
Scotsburn
N
0 15 30 Metres
0 50 100 Feet
LOCATION MAP
SAWMILL BK
QUARRY
Pictou
104
New
Glasgow
Stellarton
0 15
km
SMB-86-5
0 Overburden
10 Red brown sandstone
Grey brown sandstone
36 Brown siltstone / mudstone
45
Feet
SMB-86-6
0 Overburden
16 Red brown siltstone
21 Red brown sandstone
36 Grey brown sandstone
58 Red mudstone
Feet
SMB-86-1
0 Overburden
11 Mixed sandstone, siltstone, mudstone
47 Red brown sandstone
69 Grey brown sandstone
92 Red brown mudstone
157
Feet
SMB-86-4
0 Overburden
7 Grey sandstone
19 Mixed red brown siltstone, mudstone
57 Red brown sandstone
70 Grey sandstone
87
Feet
SMB-86-5
SMB-86-6
CLEARED
AREA
SMB-86-1
SMB-86-3
SMB-86-2
SMB-86-4
Quarry
25°
Sawmill
Brook

Figure 7. Sawmill Brook Quarry diamond-drill hole locations and sections.

VARIOUS COMMODITIES PROJECT*

R. H. MacDonald

A Various Industrial Mineral Commodities Project, funded under the Canada - Nova Scotia Mineral Development Agreement (CNSMDA), was initiated in May 1986 to update and improve the database on several industrial mineral commodities which occur throughout the Province. These commodities include those presently sought after in the market place (i.e. andalusite, barite, beryl, brucite, celestite, dolomite, garnet, graphite, limestone, silica, spodumene, topaz, wollastonite and zeolites) as well as others that may become important as market demands change. Initial emphasis has been placed on the former group, which includes high calcium limestone and high magnesium dolomite and to a lesser degree andalusite, barite, celestite, garnet, graphite and silica.

The majority of the work to date has concentrated on data compilation and field investigations of limestone and dolomite deposits. Requests for assistance in locating additional resources have been made by users presently established within Nova Scotia as well as others investigating the possibility of utilizing provincial resources.

During the past field season, 140 limestone and dolomite deposits were investigated and the most promising of these were sampled and assayed. The present demand is for high calcium limestone deposits near existing user facilities and for large tonnage specialized grade dolomite deposits at or near deep water shipping points. A report (NSDME OFR 86-064) has been completed on the major limestone/dolomite deposits of Nova Scotia. Pertinent data are presented in a single sheet format for easy access by interested persons.

A program of data compilation and field investigations has also been established for the other industrial mineral commodities previously mentioned. An in-depth study of Nova Scotia Department of Mines and Energy assessment and open file reports has defined deposits that were

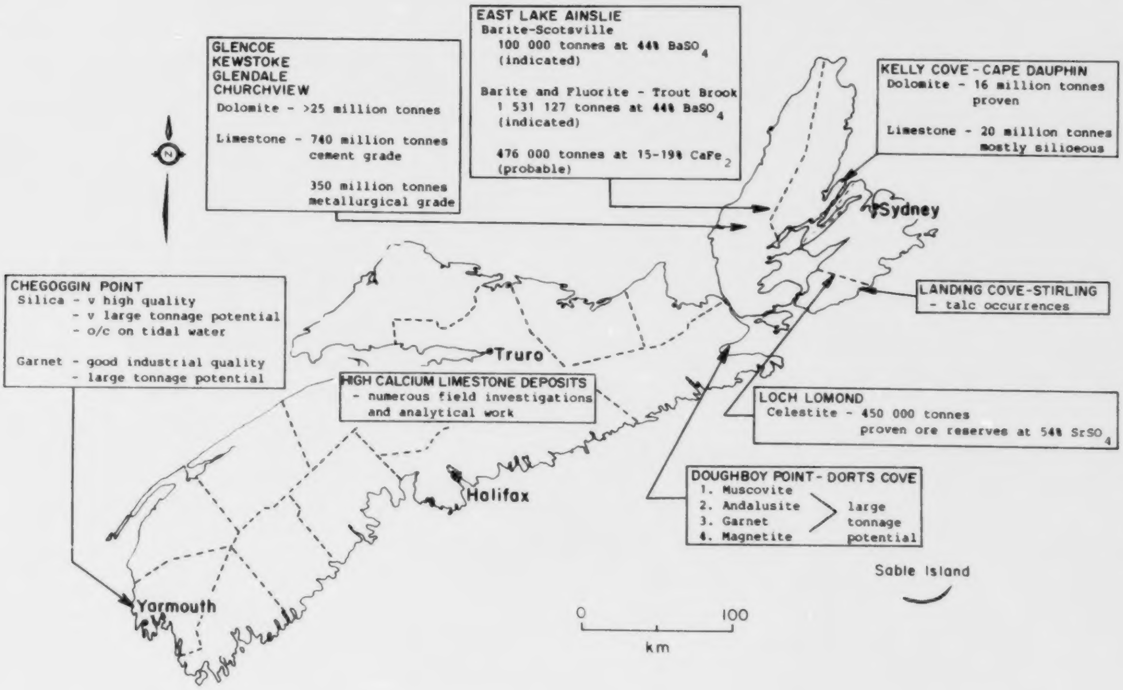
GLENCOE
KEWSTOKE
GLENDALE
CHURCHVIEW
Dolomite - >25 million tonnes
Limestone - 740 million tonnes cement grade
350 million tonnes metallurgical grade
EAST LAKE AINSLIE
Barite-Scotsville
100 000 tonnes at 44% $BaSO_4$ (indicated)
Barite and Fluorite - Trout Brook
1 531 127 tonnes at 44% $BaSO_4$ (indicated)
476 000 tonnes at 15-19% $CaFe_2$ (probable)
KELLY COVE - CAPE DAUPHIN
Dolomite - 16 million tonnes proven
Limestone - 20 million tonnes mostly silioeous
N
Sydney
CHEGOGGIN POINT
Silica - v high quality
- v large tonnage potential
- o/c on tidal water
Garnet - good industrial quality
- large tonnage potential
LANDING COVE-STIRLING
- talc occurrences
Truro
HIGH CALCIUM LIMESTONE DEPOSITS
- numerous field investigations and analytical work
LOCH LOMOND
Celestite - 450 000 tonnes
proven ore reserves at 54% $SrSO_4$
DOUGHBOY POINT - DORTS COVE
1. Muscovite
2. Andalusite
3. Garnet
4. Magnetite
large tonnage potential
Halifax
Sable Island
Yarmouth
0
100
km

Figure 1. Location of major deposits investigated in 1986.

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

once less attractive but have potential today due to recent increased value of the commodity and improved refining techniques. Figure 1 locates the major deposits that have been investigated during the 1986 field season. These deposits include the Chegoggin Point - Lake George high grade silica and garnet deposit, the alumina/andalusite deposits at Dorts Cove and Doughboy Point, Guysborough County, talc occurrences at Landing Cove and Stirling, Cape Breton Island, and the limestone/dolomite deposits of Glencoe, Kewstoke, Glendale, Churchview, Kellys Cove, Cape Dauphin, Ingonish, Admiral Rock, Brookfield and Meander River areas. Beryl and spodumene deposits in southwestern Nova Scotia, and various graphite, wollastonite, celestite and titanium occurrences are not included. Topaz, a by-product of the East Kemptville tin mine, has been sampled and assayed with the hope of finding a suitable market.

Future plans for the Various Commodities Project include trenching and drilling programs on selected deposits in order to further prove their potential for development. The data compiled during this project will be presented in a final report and will also be available by searching for the desired commodity on the departmental computer. All data will eventually be readily available to the public.

MINERAL INVENTORY

N. A. Lyttle

BIBLIOGRAPHIC DATABASE ACTIVITIES*

(J. Gillespie-Wood, D. Wilkinson, D. MacDonald, K. Lindgreen, K. Billard, B. Hawkins)

Indexing and on-line data entry into GEOSCAN continued throughout 1986 for Nova Scotia Department of Mines and Energy bibliographic records. GEOSCAN is a bibliographic database which provides access to publicly available geoscience literature concerning the Canadian landmass and offshore regions. The database presently contains over 98,000 records. The database is co-operatively produced from the indexing contributions of twelve federal, provincial and professional geoscience organizations located throughout Canada. The Geological Survey of Canada, through the National GEOSCAN Centre, co-ordinates these indexing activities and provides computer resources in support of this project.

In 1986, 1259 new Nova Scotia Department of Mines and Energy records were added to GEOSCAN. They consisted of 203 assessment reports, 761 open file maps, 146 open file reports, 67 publications, 4 theses and 78 journal literature references, representing a 15.5% growth in the size of the Nova Scotia component of the database. As of November 30, 1986, the database contained 8822 Nova Scotia Department of Mines and Energy records consisting of 3916 assessment reports, 1641 publications, 1136 journal literature references, 801 open file maps, 731 open file reports and 597 theses.

A new, five-year bibliographic index, entitled Report 86-2 Index to Assessment Reports 1981 to 1985 (with Keyword and Map Indexes), was released in October 1986. The corresponding index Report 86-4 Index to Publications, Open File Reports, Open File Maps and Theses 1981 to 1985 is in press, and will be published early in 1987.

Providing public access to GEOSCAN is an accepted goal of all the participating organizations involved in the support of GEOSCAN. In order for GEOSCAN to receive the widest possible public exposure and to best serve the end-user, GEOSCAN will be marketed through one or more of the established database vendors in Canada. At present, vendor responses to the marketing of GEOSCAN are being solicited, and it is anticipated that GEOSCAN will be publicly accessible through one or more vendors early in 1987. In anticipation of GEOSCAN becoming publicly available on-line, the conversion and standardization of Nova Scotia Department of Mines and Energy records that began in 1984 has now been virtually completed. By the time the database is available for public on-line enquiry, all our records should be available to be searched.

MINERAL OCCURRENCES DATABASES ACTIVITIES*

(G. DeMont)

Information from the Metallic and Industrial Mineral Occurrence Data (MOD) cards has been used to create the Metallic and Industrial Mineral Occurrences Databases. These databases reside on a Digital PDP 1173 computer, using GEOBASE, a geographic information system (GIS) software package at the Maritime Resource Management Service (MRMS) in Amherst, Nova Scotia. MRMS will provide copies of the databases on magnetic tape, the results of custom searches of the databases, and plots of mineral occurrences upon request, on a fee-for-service basis. Complete listings of the contents of both mineral databases were published as Open File Reports 599, 600 and 601 Metallic Mineral Occurrences Maps and Data Compilations and Open File Reports 606, 607 and 608 Industrial Mineral Occurrences Maps and Data Compilations, covering central, eastern and western Nova Scotia, respectively.

Since the publication of Open File Reports 599, 600, 601, 606, 607 and 608, the MOD card files and the mineral occurrences databases have been updated from information gathered from all assessment reports, open file reports and publications available during the years 1981 to 1985, and from the results of department field work carried out in these years. One hundred fifty-nine new metallic mineral occurrences and 21 new industrial mineral occurrences were added to the databases from this update. The Metallic Mineral Occurrences Database now contains information on 1053 mineral occurrences, and the Industrial Mineral Occurrences Database now contains information on 1073 industrial mineral occurrences.

The updated version of the metallic mineral occurrences database has been installed on an IBM-AT microcomputer, using dBASE III PLUS as the database management software. Copies of the metallic mineral occurrences database, or the results of custom searches of the database, can be made available on diskette. Installation of the industrial mineral occurrences database on the microcomputer will be undertaken in 1987.

DRILLHOLES DATABASE ACTIVITIES*

(G. DeMont, D. Jakobsen)

Information on drilling in mineral exploration assessment reports has been used to create the Drillholes Database. As with the mineral occurrences databases, this database resides at MRMS, on a PDP 1173 computer using GEOBASE software. Copies of the database, custom search results, and drillhole plots can also be obtained from MRMS on a fee-for-service basis. Complete listings of the contents of the Drillholes Database were published in June 1986 as Open File Reports 86-019, 86-020 and 86-021 Drillhole Compilations from Open Assessment Reports covering central, eastern and western Nova Scotia, respectively. The information in these reports covers all open assessment reports available up the end of December 1985. Approximately 10,000 drillholes are represented in these open file reports.

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*Funded by the Nova Scotia Department of Mines and Energy, and by the Canada - Nova Scotia Mineral Development Agreement

During the summer of 1986, a project was underway to add to the database all the drillholes reported in the departmental publications Drilling Logs of Government Core Drills, which are available from 1901 to 1985. Approximately 6000 drillholes have been coded, extending from 1985 back to 1957, of which 3150 have been entered into the database as of November 30, 1986.

As with the mineral occurrences databases, it is planned to install the Drillholes Database on the microcomputer and make copies of the database or the results of custom searches available on diskette.

GOLD BIBLIOGRAPHY ACTIVITIES*

(J. Gillespie-Wood)

Compilation of information for the gold bibliography, to be entitled Gold in Nova Scotia: a Bibliography of the Geology, and Exploration and Mining Histories from 1832 to 1986, is well advanced and publication is expected in 1987. The 500 page bibliography will contain over 1300 references, documenting over 325 gold districts and occurrences. The bibliography will be organized into three parts: Part I will be an alphabetic author index; Part II will be an index by gold district, with each gold district being subdivided into an author index, an assessment reports index and a map and cross-section index; Part III will contain the following cross reference lists - (1) gold district/NTS map/county, (2) NTS map/gold district/county and (3) county/gold district/NTS map.

MINERAL RESOURCE PROMOTION*

R. R. Potter

INTRODUCTION

The Nova Scotia Department of Mines and Energy (NSDME) and Energy, Mines and Resources Canada (EMR) have completed a large number of geological, geochemical, geophysical, metallurgical, financial and market studies related to provincial mineral resources. It is the purpose of this project to research and compile this technical information in order to identify and promote new opportunities related to further development of the Nova Scotia mineral industry. The objectives of this project are:

1. To assess all available data on the geology and mineral resource potential of Nova Scotia and identify those metals, minerals or commodities with the greatest potential for exploration or development investment.

2. To prepare a series of consumer-oriented brochures on all metals, minerals or commodities (i.e. ferrous metals, agricultural minerals) that occur in the Province.

3. To prepare a Mineral Industry Profile which will provide data on mineral resources, mining law, taxation, transportation, port facilities, etc.

A brief review of the technical literature was completed and a general paper "Nova Scotian Mineral Resources: Opportunities in New Investment, New Products and New Markets" was presented at the Annual Meeting of the Mining Society of Nova Scotia in June 1986. This was followed by visits to producing mines, significant mineral deposits and mineral occurrences. For promotional purposes, it was necessary and desirable to develop a new classification system of consumer-oriented metals, minerals and commodities. The grouping system presented here will provide the basis for the proposed promotional brochures. Preliminary observations related to each group are based on literature review, field examinations and discussions with departmental staff and representatives of companies working in the Province.

PRECIOUS METALS - GOLD, SILVER, PLATINUM AND PLATINUM GROUP METALS

Metals of this group have a variety of uses, including jewellery, coinage, electronics, photography, medicine, dentistry, petroleum refining and metallurgy.

Large areas of Nova Scotia have potential for gold. Recent exploratory work indicates the presence of deposits in excess of 2 million tonnes grading 0.20 - 0.30 ounces per tonne with many opportunities for well financed exploration programs. Platinum values have been reported in some deposits and antimony, arsenic and tungsten minerals are locally abundant. In Nova Scotia, high silver values are more commonly associated with barite-lead-zinc deposits.

ELECTRONIC METALS - BERYLLIUM, CADMIUM, CESIUM-RUBIDIUM, GALLIUM, GERMANIUM, INDIUM, MERCURY, SELENIUM-TELLURIUM, THALIUM

A large number of minor metals are finding special uses in the electronic industries because of their unique physical, chemical, electrical or photo-electrical properties. These metals are also used in the manufacture of communication equipment, lasers, infra-red and fibre optics, and detectors as well as in medical technology, xerography and power generation. They are used, to a lesser extent, in the making of special alloys, coatings and glass.

Small amounts of these high priced metals have been recognized in both base metal and coal deposits. If present and recoverable, these metals could have a very positive effect on the economics of such deposits.

FERROUS METALS - COBALT, CHROMIUM, NIOBIUM-TANTALUM, IRON ORE, MANGANESE, MOLYBDENUM, NICKEL, TUNGSTEN, VANADIUM

These metals are utilized in the production of steel and ferroalloys as well as special or "super" alloys. Small amounts are used in non-ferrous alloys and as coatings for the aerospace, tool, machinery, oil-gas, construction and transportation industries. Other metals used in small amounts for these purposes include aluminum, cadmium, rhenium, titanium, zirconium-hafnium and strontium.

Nova Scotia iron deposits should be evaluated for the presence of minor metals such as gold, silver, vanadium and manganese. Iron carbonates and barite have been produced from deposits along the Cobequid Fault. The possibility of other minerals, such as gold, silver, copper, lead, zinc, cobalt and antimony occurring in the same structural environment is considered good. Vanadium, a strategic metal for Canada, is known to occur in shales containing Dictyonema (0.2 - 1.0% V_2O_5). Devonian shales in the Annapolis Valley area contain this fossil and discovery of strata with economically interesting vanadium values may be possible.

LIGHT CONSTRUCTION METALS - ALUMINUM, MAGNESIUM, TITANIUM

The aerospace and transportation industries use the greatest percentage of these metals. The remainder is consumed by the chemical, metallurgical and electrical industries.

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*Funded by the Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

Andalusite-bearing schists with up to 25% alumina occur in Nova Scotia, and dolomites with potential for magnesia production are found on Cape Breton Island. These deposits may have potential for development if low cost power is available, or if new processes are found to produce alumina and magnesia.

INDUSTRIAL METALS - ANTIMONY, ARSENIC, BISMUTH, COPPER, LEAD, TIN, ZINC

Metals of this group have a wide variety of uses as alloys and coating in the agricultural, transportation, construction, chemical glass-ceramic, pharmaceutical and electrical industries.

There is good potential for the discovery of auriferous stibnite deposits in Nova Scotia, particularly within the Meguma Group in which the arsenic mineral arsenopyrite is locally abundant. Antimony, arsenic and bismuth are not currently produced but if discovered in commercial quantities would provide an added diversity to the Province's mineral resource base. North America's only tin mine is located at East Kemptville, and the potential for discovering additional deposits is considered good. In general, Nova Scotia copper, lead and zinc deposits are metallurgically simple and are characterized by high mineral recoveries. Silver is anomalously high in deposits associated with barite, and the presence of precious metals plus other minor metals consumed by the electronics industries could have a positive effect on the economics of these deposits.

ABRASIVES - ALUNITE, CORUNDUM, GARNET, QUARTZ AND QUARTZITE, TOPAZ

These minerals, because of their unique physical properties, are used in the preparation of coated papers, cutting tools, polishing compounds and skid resistant surfaces. Limestone, zircon and diatomite are also used in small quantities.

Anomalous concentrations of garnet are known at several localities within the Meguma Group, but further work is required to determine if it is technically or economically feasible to produce and market abrasive grade garnet. Topaz, another potential abrasive, is associated with the tin ore at East Kemptville. Quartz and quartzite for use as abrasives occur in many areas of Nova Scotia and the production of these and other abrasives would be compatible with government policy related to the development of new products.

AGRICULTURAL MINERALS - ANHYDRITE, DOLOMITE, LIMESTONE, NITROGEN (FIXED), PEAT, PHOSPHATE, POTASH, SALT, SULPHUR

The agricultural and food industries are a large consumer of these minerals which form the basis of fertilizers, animal feeds, soil conditioners and other agri-chemicals. Boron, iodine, diatomite and selenium are also used in small quantities.

Nova Scotia is well located to produce the high tonnage low unit value minerals consumed by the agricultural industry. Most of these minerals are currently produced in the Province, the exceptions being phosphate, potash, sulphur and nitrogen. There is potential for nitrogen production (urea or ammonia) from methane or natural gas. Potash and phosphate rocks are also known, but further exploration is required. Elemental sulphur has also been discovered near Truro, and work is in progress to determine the feasibility of producing sulphur from anhydrite. Ammonium sulphate may also be produced by reacting methane with gypsum and anhydrite, however the economic feasibility of producing this basic fertilizer ingredient in Nova Scotia remains to be investigated.

CHEMICAL AND METALLURGICAL RAW MATERIALS - BORON, BROMINE, CELESTITE, FLUORSPAR, DOLOMITE-LIMESTONE, KAOLIN, LITHIUM, MICAS, RARE EARTHS, RHENIUM, SALT, SILICA, SULPHUR, TALC, TITANIUM DIOXIDE, WOLLASTONITE

These metals and minerals are used principally in the smelting, refining, petroleum, petrochemical, plastics, rubber, chemical, paint, adhesive, sealant, soap and related industries. They are used as basic feedstocks, foundry sands and dressings, catalysts and fluxes. Small quantities of barite, limestone (as precipitated calcium carbonate), diatomite, mica, graphite and silica are also used.

Most of these minerals occur in Nova Scotia. Salt is currently produced at Nappan and Pugwash, but only Pugwash produces rock salt. Evaporated salt for the chemical industry is produced at both locations. North America's second largest strontium deposit is located in the Lake Enon area, Cape Breton Island. A large number of fluorspar deposits in the Lake Ainsle area of Cape Breton Island are currently being evaluated. Bromine, iodine and lithium are normally recovered from brines, however it is not known if Nova Scotia's saline wells contain economically significant concentrations of these elements. Limestone and dolomite are currently produced and there are several large deposits (particularly on Cape Breton Island) that remain to be developed. Kaolin also occurs in central Nova Scotia and lithium minerals have been found in the southwestern part of the Province near Yarmouth. Rhenium, a high priced metal used in the production of low lead gasoline, has been reported to occur in the Province. Sandstone-hosted copper deposits warrant careful examination for rhenium. A large, very high grade quartz deposit is located on the coast near Yarmouth. Talc and wollastonite also occur in the Province but further exploration is required to evaluate their economic potential.

PULP AND PAPER RAW MATERIALS - DIATOMITE, LIMESTONE, KAOLIN, SALT, SULPHUR, SODIUM SULPHATE, TALC

The pulp and paper industry is the main consumer of these minerals. They are used for caustic soda-chlorine production or as other basic raw materials such as coatings, fillers and extenders required for the production of fine papers. High grade natural salt suitable for the production of caustic soda-chlorine is currently produced at Pugwash.

Limestone and kaolin occur in the Province. Some work may be required to ensure they meet the specifications for production of fine paper. Both talc and pyrophyllite have been identified on Cape Breton Island. The production of any or all of these minerals could find a ready market in the pulp and paper industry of the Atlantic region.

GLASS AND CERAMIC RAW MATERIALS - QUARTZ, BALL CLAY, BORON, FELDSPAR, FIRECLAY, FLUORSPAR, LIMESTONE, SODA ASH

The glass and ceramic industries are the principal consumers of quartz and certain clays. Smaller quantities of other minerals are also used.

Nova Scotia has a well established brick and tile industry which uses local clays. Most of the other minerals occur in the Province, and soda ash could be produced locally if a suitable market could be developed.

REFRACTORIES - GRAPHITE, MAGNESIUM MINERALS (BRUCITE, MAGNESITE), QUARTZ, SILLIMANITE GROUP (ANDALUSITE, KYANITE, SILLIMANITE, MULLITE)

Minerals of this group are used in the manufacture of refractory bricks and other products for use at high temperatures.

Although none of these minerals are currently produced in Nova Scotia, occurrences of brucite and magnesite are known and a graphite deposit is now being evaluated. Also, potentially large deposits of quartz and andalusite are well located on tidewater in the western and eastern parts of the Province. Further work is required to determine the feasibility of producing and marketing these minerals.

CONSTRUCTION RAW MATERIALS - ASBESTOS, BARITE, CEMENT, CLAY-SHALE, DIMENSION STONE, GYPSUM, LIMESTONE, MICA, PERLITE, ROCK WOOL, TALC-PYROPHYLLITE, VERMICULITE, SAND, GRAVEL AND CRUSHED ROCK

This group includes all minerals and commodities associated with the construction industry, including extenders for sealants, fillers and adhesives. Nova Scotia is a well established producer of raw materials for the construction industry.

The Walton barite deposit, at the time of its discovery prior to World War II, was the largest deposit of this mineral in the world. From 1941-1978 it produced about 4.3 million tonnes of barite. Since then a number of high-grade deposits have been found elsewhere in the Province and small amounts of barite have been produced. A large, modern cement producer is located at Brookfield and a number of other cement grade limestone deposits are known. Nova Scotia is the largest producer of gypsum in Canada. Attractive granite and sandstone for public buildings and monuments have been quarried at several places, and opportunities for expanding this industry are now being investigated. Nova Scotia is a large producer of sand, gravel and crushed rock. In fact the existence of all-weather, deep water ports facilitates the barging of aggregate south along the eastern seaboard to the Gulf of Mexico. Nova Scotia has many opportunities for those involved in the production of raw materials for the construction industry.

EXPLORATION RAW MATERIALS - BARITE, SPECIAL CEMENT, BENTONITE, SYLVITE, HALITE, HEMATITE, MICAS AND CLAYS

These minerals are used in the preparation of drill fluids, cements and special cements. Small quantities of many other minerals are also used.

In recent years, locally produced barite has been used in offshore petroleum and gas exploration. Suitable material may be produced from a number of deposits if and when additional material is required. Small quantities of other minerals used in the preparation of special drilling muds (i.e. sylvite, halite, hematite, calcite, mica, gypsum, silica sand, graphite, diatomite and magnesite) are also found in the Province.

FILTERS AND ADSORBANTS - DIATOMITE, FULLERS EARTH, ZEOLITES

Minerals and materials of this group have unique adsorbant properties that preclude substitution. Other minerals, however, can be used for filters aids.

Although filter grade diatomite has yet to be found in Nova Scotia, fullers earth has been identified near Londonderry, Colchester County and at Lake Ainslie, Inverness County. Zeolites are widespread in gently dipping Triassic mafic flows on the shores of the Bay of Fundy, but little work has been done to determine if it is economically feasible to mine and extract these minerals for use as adsorbants or filters.

GEMS AND SEMI-PRECIOUS STONES - AGALMATOLITE, AGATE, AMETHYST, CHALCEDONY, JASPER, TOPAZ, TOURMALINE

These minerals are obtained for jewellery and other decorative ornaments.

Amethyst and agate are the most prevalent and popular semi-precious stones obtained in Nova Scotia. Their recovery from Triassic flows in the Bay of Fundy area provides partial employment for a number of people, however it is not known if there are opportunities for expanding this small industry.

SOLID MINERAL FUELS - COAL, OIL SHALE, PEAT

These materials are used principally for the generation of electricity or for the production of coke for metallurgical applications.

Nova Scotia produces about 3 million tonnes of coal annually, mainly for thermal electric power generation. Most of this production is obtained from the Sydney area. The total coal reserves of the Province are estimated to be in the order of 3 billion tonnes. Future production may be achieved from identified deposits in the Stellarton, Inverness and Springhill areas. There may be opportunities for new products derived from coal production. They include methane drained from coal mines, or coke from coal currently mined in the Sydney coalfield. Research is also continuing in the development of coal-oil and coal-water mixtures. Oil shales and fuel peat occur in the Province and work is in progress to determine the optimum use of these resources.

LIQUID-GASEOUS HYDROCARBONS - PETROLEUM, NATURAL GAS

These hydrocarbons are used principally for fuels, with numerous co-products such as elemental sulphur and chemicals for the agricultural and other industries.

Nova Scotia has large offshore areas with oil-gas potential. The Venture Field near Sable Island has reserves in the order of 2.36 T.C.F. of gas. Significant new oil-gas discoveries have been made in the same genral area. As only 117 wells have been drilled on the Scotian Shelf, opportunities for discovering additional reserves are considered good.

UNDERGROUND STORAGE - SALT AND GRANITIC ROCKS

Areas underlain by these rocks are used in places for the storage of strategic petroleum supplies, natural gas, liquified petroleum gas and liquified natural gas, or compressed air.

Nova Scotia has large areas underlain by salt of Carboniferous age which have potential for underground storage. A number of areas are well located for use in conjunction with future petrolum-gas developments.

SUMMARY

Existing technical reports published by the Nova Scotia Department of Mines and Energy on metals, minerals and commodities such as iron, manganese, limestone and dolomite, barite and fluorite, will form the basis of a promotional report summarizing information for individual investors or companies who may be unaware of the Province's mineral resource potential. Information on mining law, climate, highways, railroads, harbours, bulk loading facilities, power costs, taxes and incentives will also be included.

GOLD INVENTORY PROJECT*

C. K. Miller

The Gold Inventory Project is a comprehensive compilation and economic evaluation of gold, silver and platinum occurrences in Nova Scotia. The project commenced in December 1984 and will conclude in September 1987. The aim of the project is to produce a database that will provide a sound basis for exploration and mineral deposit studies.

It is significant, from an exploration standpoint, that gold has been deposited hydrothermally (primary) and mechanically (secondary) in rocks of Early Carboniferous age. In addition to primary gold occurrences at Smithfield, Copper Lake and Crow Point (Miller, 1986), significant gold values have been obtained from copper deposits at Ohio, Antigonish County. Gilpin (1884) reported that "an opening has been made on an occurrence of yellow and grey copper ore. Samples have yielded 6.6 dwt/ton Au (.33 oz/ton) and 30 oz/ton Ag". At Hilden, Colchester County, reddish sandstones of the Horton Group have been silicified and injected with white quartz stringers containing minor pyrite. Grab samples from the prospect have yielded 0.05% W, 0.02 oz/ton Au and 1.80 oz/ton Ag (Cole, 1951). Cole described the rocks exposed in a trench as being altered and sheared. No significant gold values were obtained from samples collected during the 1986 field season, but the silicification and veining requires further investigation.

With regard to paleoplacer gold occurrences in Early Carboniferous age rocks, in 1895 a staking rush took place in the Brookfield area, Colchester County, after it was reported that gold had been found in a quartz-pebble conglomerate. In 1891, sworn returns from a stamp mill at Waverley indicated that 4 tons of conglomerate from Brookfield yielded 1.2 oz. Au (0.30 oz./ton). During the summer of 1986, the occurrence was located and sampled. One sample of the quartz-rich matrix to the quartz pebbles yielded 1280 ppb Au.

A gold-antimony occurrence was investigated at Landsdowne, Digby County, within slates of the Halifax Formation. Exposure is poor and no _in situ_ mineralization was observed. Some specimens, well mineralized with stibnite, were found in some of the old dumps. The samples were anomalous in As (100-3000 ppm), Ag (52 ppm), Sb (>3000 ppm), barium (1200 ppm), W (2600 ppm) and Au (63-550 ppb), in addition to Cu, Pb and Zn. Similar mineralization found near Waldeck West, Digby County, by prospector Mert Stewart, was also investigated and sampled. This occurrence is 7.5 km northeast of the Landsdowne prospect. Stibnite, pyrite and acicular arsenopyrite occur as disseminations and patches in quartz veins, and in joint and cleavage planes of the slate. This mineralization is spatially related to seemingly unmineralized lamprophyre dykes. Assays of the mineralized samples indicate anomalies in As, Sb, Ba, Ag and Au, similar to metal concentrations at Landsdowne. A sample of the lamprophyre dykes indicated 881 ppm Sb, 446 ppm As and 82 ppb Au. A sample of pyritic slate indicated 507 ppm Sb and 358 ppb Au. Gold-antimony mineralization may be more widespread in this region than previously recognized.

The final output of the project will be a catalogue of all the gold, silver and platinum occurrences, prospects or former mines. The geological setting and character of mineralization will be described for each occurrence and a location map will be included.

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MINERAL LAND USE POLICY DEVELOPMENT*

D. B. Hopper and C. A. Dobson

The Mineral Land Use Policy Development Project was initiated under the Canada - Nova Scotia Mineral Development Agreement to promote proper management and protection of mineral resources by providing information, interpretation and resource management to the provincial and municipal planning community. This community consists of planners and surface resource managers who are responsible for designating future land use in Nova Scotia. Currently, the staff of the Mineral Land Use Policy Development Project is gathering mineral resource land use information on mineral industry requirements relative to the needs of other resource sectors, in order to present a perspective on how and where the mineral resource sector should fit into a provincial land use policy.

MINLU - A MINERAL LAND USE INFORMATION BASE

The project's first phase involves extensive information gathering for the creation of MINLU - a mineral land use database. MINLU will contain information on lands that preclude exploration and mining activity as well as those lands where industrial activity is limited in some way. Sets of Mineral Resource Land Use (MRLU) Handbooks with maps are also being compiled for MINLU. Currently, work is progressing on 14 NTS map sheets covering Halifax County. Information plotted on the MRLU maps has been collected from a number of sources within the Nova Scotia Department of Mines and Energy. These sources include several inventories compiled by the Department such as sand and gravel, mineral occurrences, peat, diatomite and building stone; land use files; the drillhole database; GEOSCAN; files on abandoned mine shafts (operation minecap); coal resource files; and other data found in publications, reports and maps. The products derived from MINLU will include 24 MRLU Handbooks with maps, each set representing a rural municipality. These handbooks will be made available as departmental reports in hard copy and on computer data diskettes. An IBM-PC AT microcomputer will be used to automate the database and produce the diskettes for municipal land use planners and resource managers.

Another aspect of MINLU is the collection and organization of information from other surface resource sectors. As part of its resource management responsibilities, the Nova Scotia Department of Mines and Energy monitors land use policies being developed by other resource sectors such as forestry, fisheries, agriculture and recreation. In an environment of complex, multiple land use issues shared by several resource sectors, the Department's consultation with other resource managers is crucial.

The project is broad in scope and encompasses many aspects of the Province's natural resource sectors. This year a land use planner was added to staff to assist with the project's growing workload and to increase the production rate of the MRLU Handbooks.

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*Funded by the Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

ALTERATION HALOES AND THEIR IMPLICATIONS FOR GOLD MINERALIZATION IN THE MEGUMA GROUP OF NOVA SCOTIA*

D. J. Kontak and P. K. Smith

INTRODUCTION

Alteration is a universal feature associated with all deposits of hydrothermal origin, although the size and types of alteration may vary due to a variety of physical and chemical parameters (Henley and McNabb, 1978; Cathles, 1981). The study of such phenomena is important in terms of understanding the genesis of the deposits and, if fully appreciated, may offer a viable exploration target on both a district and deposit scale (e.g. Hodgson et al., 1982). With specific reference to gold mineralization, diagnostic alteration styles have been recognized in Archean lode-gold deposits (Colvine et al., 1983), Carlin or sediment-hosted precious metal deposits (Bagby and Berger, 1985; Bakken and Einaudi, 1986), epithermal deposits (Berger and Bethke, 1985), quartz vein systems (e.g. Yellowknife district: Kerrich et al., 1977; Allison and Kerrich, 1981), and large porphyry gold deposits (Sillitoe, 1979). In all of these instances, the scale of the alteration exceeds the mineralized vein systems indicating, that the scale of the respective paleohydrologic system was considerable.

Historically, the Meguma Group gold deposits were considered to be well defined quartz-lode systems, namely "saddle-reefs" or Bendigo-types (e.g. Keppie, 1976; Graves, 1976; Boyle, 1979; Graves and Zentilli, 1982) lacking alteration haloes (Boyle, 1979). The mineralization was considered to be confined predominantly to the quartz zones, although sulphide mineralization (e.g. arsenopyrite) adjacent to the veins indicated some lateral migration of the fluids into the surrounding host rock.

A preliminary study of wall rock alteration by Boyle (1979) at the Caribou deposit (Bell, 1948) indicated considerable elemental enrichment in the host greywackes over a few metres adjacent to mineralized quartz veins. More recently, Crocket et al. (1986) determined that at the Harrigan Cove property the host slate and greywackes are enriched in Au (8.0 and 8.7 ppb, respectively) and As (549 and 972 ppm, respectively) compared to similar lithologies from unmineralized districts. However, these latter did not recognize distinct alteration types associated with the geochemical enrichment of Au and As. Thus, the only previously documented occurrence of extensive alteration associated with the Meguma Group gold deposits is that of Smith (1983) for the Cochrane Hill deposit. Considering the well documented occurrence of extensive alteration at gold deposits located worldwide, the lack of descriptive information of such features in discussions of the Meguma Group gold deposits is striking. This paper presents for the first time data supporting the existense of widespread alteration haloes associated with gold deposits occurring in the eastern part of the terrain underlain by the Meguma Group.

FIELD STUDIES: OCCURRENCE, EXTENT AND NATURE OF THE ALTERATION

During the field season (June-August, 1986) approximately 30 gold districts (Malcolm, 1929) were visited in the eastern Meguma Terrane (Fig. 1) as part of a long term project designed to evaluate the potential of gold mineralization in the Meguma Group (Smith and Kontak, 1986). One of the more prominent features noted was the presence of variably developed alteration zones within the gold districts. The types of alteration recognized (i.e. silicification, carbonitization, phyllic, tourmalinization) are similar to those documented in gold deposits located worldwide and found in rocks of all ages. However, with respect to the Meguma Group deposits, the silicification of the greywacke lithologies is the most conspicuous and impressive of all the alteration types and, therefore, forms the focus of this discussion.

The silicification is easily observed in drillcore as the smooth, polished surface induced by the drilling process (Fig. 2) enhances the colour contrast between fresh and altered rocks. The fresh greywackes are generally dark grey to blue or brownish with medium grained equigranular texture which contrasts markedly with the variably bleached greywackes resulting from alteration. The alteration gradually progresses from an initial mottled or irregular spotted texture to intense bleaching with accompanying change in the texture to a finer grained, massive and highly indurated rock. In extreme cases the alteration process culminates in the formation of fine grained, granular quartz veins. These veins are similar to some of the massive, fine grained quartz veins seen in areas devoid of alteration.

The alteration process is not uniquely associated with obvious veinlets of quartz and associated mineralization as is typically the case, for example, in greisen systems (Korzhinskii, 1970; Scherba, 1970) or porphyry copper (Lowell and Guilbert, 1970) and molybdenum (White et al., 1981) systems. In the rare cases that quartz veins are observed within alteration zones, the silicification is not symmetrically disposed about the vein reflecting, perhaps, a late stage injection of the vein material. The alteration is, however, strongly controlled by

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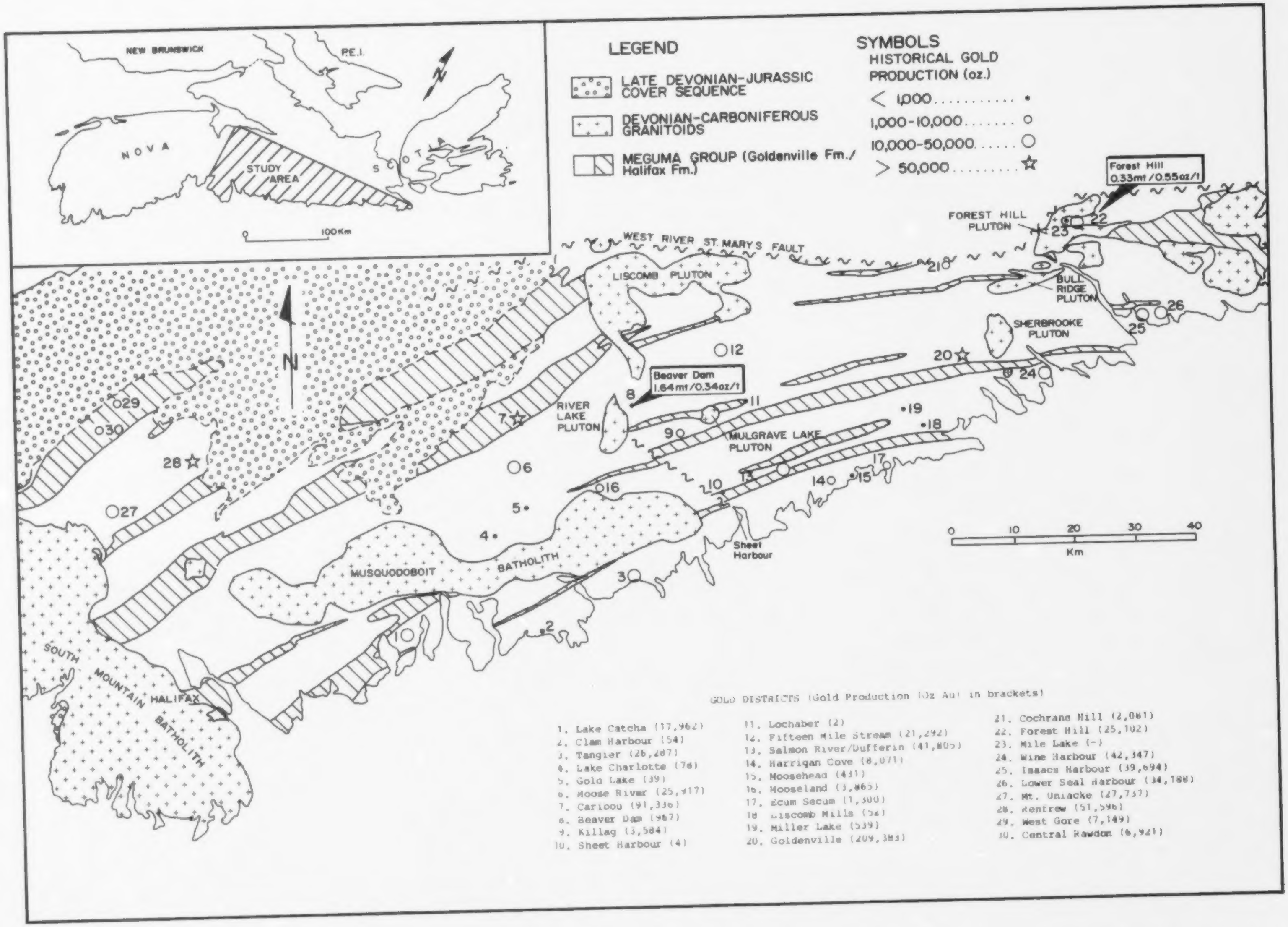
NEW BRUNSWICK
P.E.I.
N O V A
S C O T I A
STUDY AREA
0
100Km
LEGEND
LATE DEVONIAN-JURASSIC COVER SEQUENCE
DEVONIAN-CARBONIFEROUS GRANITOIDS
MEGUMA GROUP (Goldenville Fm./ Halifax Fm.)
SYMBOLS
HISTORICAL GOLD PRODUCTION (oz.)
< 1,000 .... •
1,000-10,000 .... ○
10,000-50,000 ..... ◯
> 50,000 .... ☆
Forest Hill 0.33mt/0.55oz/t
FOREST HILL PLUTON
WEST RIVER ST. MARY'S FAULT
LISCOMB PLUTON
BULL RIDGE PLUTON
SHERBROOKE PLUTON
Beaver Dam 1.64mt/0.34oz/t
RIVER LAKE PLUTON
MULGRAVE LAKE PLUTON
MUSQUODOBOIT BATHOLITH
SOUTH MOUNTAIN BATHOLITH
HALIFAX
Sheet Harbour
N
0
10
20
30
40
Km
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GOLD DISTRICTS (Gold Production (Oz Au) in brackets)

1. Lake Catcha (17,962)
2. Clam Harbour (54)
3. Tangier (26,287)
4. Lake Charlotte (78)
5. Gold Lake (39)
6. Moose River (25,917)
7. Caribou (91,336)
8. Beaver Dam (967)
9. Killag (3,584)
10. Sheet Harbour (4)
11. Lochaber (2)
12. Fifteen Mile Stream (21,292)
13. Salmon River/Dufferin (41,805)
14. Harrigan Cove (8,071)
15. Moosehead (431)
16. Mooseland (3,865)
17. Ecum Secum (1,300)
18. Liscomb Mills (52)
19. Miller Lake (539)
20. Goldenville (209,383)
21. Cochrane Hill (2,081)
22. Forest Hill (25,102)
23. Mile Lake (-)
24. Wine Harbour (42,347)
25. Isaacs Harbour (39,694)
26. Lower Seal Harbour (34,188)
27. Mt. Uniacke (27,737)
28. Renfrew (51,596)
29. West Gore (7,149)
30. Central Rawdon (6,921)

Figure 1. Location of study area and referred deposits in eastern Nova Scotia. Tonnage and grades for the deposits indicated were compiled using data available from The Northern Miner publication as of December, 1986.

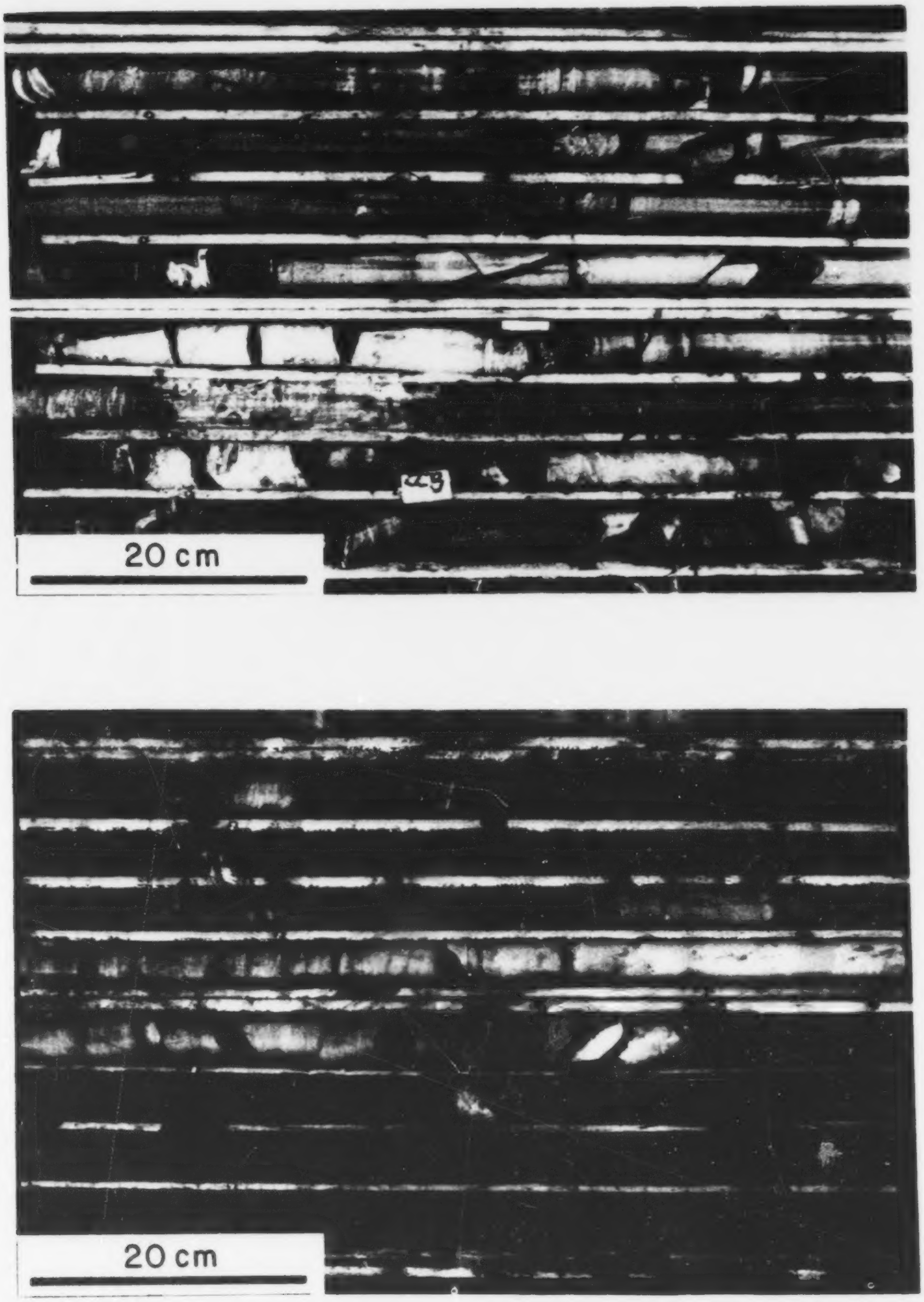

Figure 2. Sample of drillcore from the Beaver Dam deposit illustrating the bleaching effects of alteration in greywacke lithologies. The fresh rocks are the darkest. Note the extreme cases of alteration in the bottom photo where a fine grained, granular quartzite is the result of progressive alteration of the greywacke.

fracture patterns in places such that the spacing of these brittle features determines the actual extent and degree of alteration. In many cases these fractures are not observed or, alternatively, have not been preserved. It is possible that in at least some cases they may have localized later quartz veins.

The mineralogy of the alteration zones is dominantly quartz. Minor amounts of the original mineralogy may be retained depending on the degree of alteration. For example, in biotite-rich psammitic pelites silicification may impart a banded texture of alternating dark, biotite-rich bands with zones of nearly pure silica (Fig. 3). Introduction of sulphides may occur during the alteration process but further details remain to be studied.

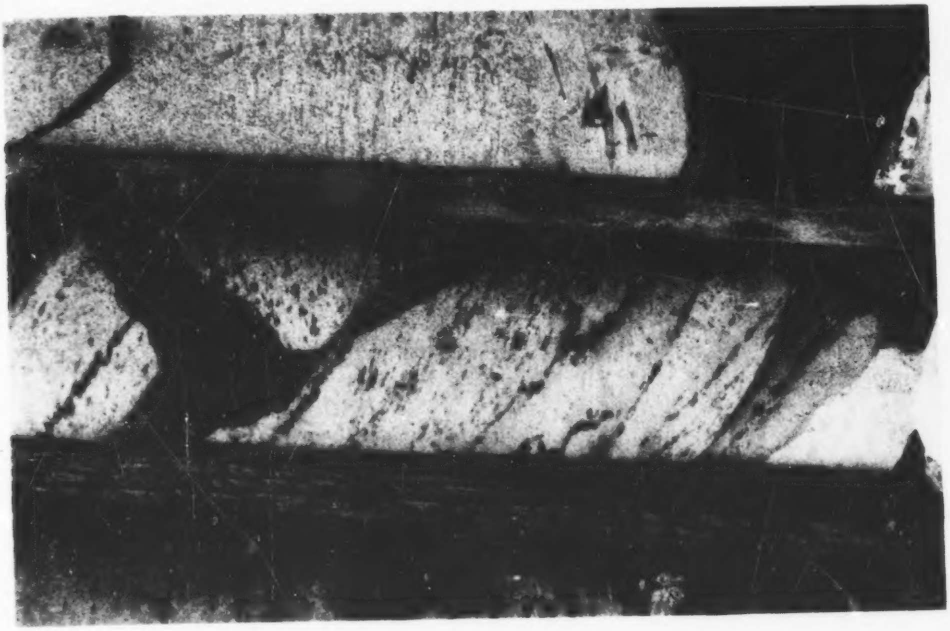

Figure 3. Sample of drillcore from the Beaver Dam deposit showing the effects of alteration in a section of semipelite. Note the alternating bands of silicified rocks and remnant biotite-rich bands. (Scale 1:1).

Although mapping of alteration zonation is not complete and definitive dimensions or geometrical shapes cannot be assigned to the haloes, a crude scale can be estimated based on the authors field observations. For example, silicification occurs along the entire strike length (>800 m) and known dip extent (>650 m) of the Beaver Dam deposit, as well as in host rocks excavated from the 200 m vertical shaft at the Forest Hill property (Fig. 4). Preliminary observations therefore dictate extremely large-scale dimensions for the alteration zones. The scale of these zones are comparable to those observed in other hydrothermal systems (i.e. epithermal environments, porphyries, etc.). At the Beaver Dam property the intensity of the alteration appears to increase with depth, coinciding with an increase in metamorphic grade of the host rocks as indicated from the distribution of andalusite, garnet, cordierite and staurolite (Smith and Kontak, 1986).

Field observations suggest that similar size alteration zones also exist at other gold districts in the study area, notable examples being Fifteen Mile Stream, Cochrane Hill, Moose River, Killag, Tangier and Lake Catcha. In all of these areas ore-grade material has been delineated from both diamond-drilling and recent underground exploration (Fig. 5). At present there appears to be an empirical relationship between the degree of alteration and the extent of mineralization. Although it is premature at this point to speculate further, this possible relationship will be investigated as more information becomes available.

Although intense silicification is easily recognized in recently drilled or blasted psammitic lithologies, this is not the case for pelites and weathered psammites. The pelitic units do not provide convincing visual evidence of alteration even when intense silicification is observed in adjacent, medium grained psammitic units. The nature of pelites may not be condusive to the penetration of hydrothermal fluids and where alteration does occur the dark colour of many pelitic lithologies makes it difficult to recognize. For this reason it is essential to be aware of the potential existence

Figure 4. Sample of bleached greywacke from the exploration shaft at the Forest Hill deposit

of alteration and to take the necessary measures to ensure it is detected (i.e. slabbing old core and weathered rocks and obtaining the freshest possible specimens).

CHEMICAL FEATURES OF ALTERATION ZONES

The problems of recognizing alteration features in the field may be partly overcome by the use of chemical analyses. A vast quantity of literature documenting the presence of alteration chemistry associated with a wide variety of hydrothermal ore deposits exists (e.g. Wilton, 1985; Lemiere et al., 1986; Cathelineau, 1983; Stemprok and Sulcek, 1969, Studemeister, 1983). Table 1 provides preliminary data for altered (silicification) rocks associated with gold mineralization from the Cochrane Hill deposit (Smith et al., 1985). Data for all the deposits is currently being compiled. The following discussion is specific to psammitic lithologies of the Cochrane Hill deposit.

MAJOR ELEMENT CHEMISTRY

Compared to the average greywacke of Wedepohl (1968) and similar unaltered lithologies from the Indian Harbour area (Smith, unpublished data), the strongly altered rocks of the Cochrane Hill area show the following features:

- marked enrichment in silica (i.e. >80 wt % SiO_2), and
- strong depletion of alumina (8 wt % vs 11-13 wt % Al_2O_3), and moderate loss of iron, calcium, magnesium, potassium and phosphorous.

Rocks that are moderately to weakly altered from visual inspection show considerably less modification of their primary major element chemistry with only a slight increase in silica and moderate loss of the alkalis. Thus, visual examination may prove to be a more useful and reliable indicator of alteration for rocks that show lesser degrees of alteration, especially when a large comparative database is not yet available.

TRACE ELEMENT CHEMISTRY

At present the trace element patterns provide little systematic variation, possibly reflecting a larger initial scatter than the major element data. Additional work and a larger sample population is required before this problem can be resolved.

RARE EARTH ELEMENT (REE) CHEMISTRY

The REE are excellent indicators of alteration processes (e.g. Wilton, 1985; Kerrich and Fryer, 1979). Preliminary data for unaltered rocks of both pelitic and psammitic lithologies from the Forest Hill area (Fig. 6) give REE patterns typical for such sedimentary rocks (Haskin et al., 1968). The very tight cluster of the data indicate an excellent control for the starting composition of the rocks from which to monitor the effects of alteration processes. In the same diagram, data for two quartz veins from

Table 1. Lithogeochemistry of variably silicified greywackes from the open pit at Cochrane Hill (Smith, unpublished data). The SiO_2 values determined by addition for samples with total = 100.00. The average composition of unaltered greywackes from greenschist and amphibolite facies from the Sherbrooke area (Smith, unpublished data) are shown in columns A and B, respectively, for comparision.

MAJOR/ TRACE ELEMENT[1]	STRONG ALTERATION[2]		MODERATE ALTERATION			WEAK ALTERATION				NO ALTERATION	
	PQ(142)[3]	PF(231)	PQ(416)	PQ(423)	PF(460)	PQ(238)	PQ(412)	PF(218)	PF(251)	A[4]	B[5]
SiO_2	80.00	67.94	72.50	81.44	73.44	64.69	76.32	68.78	69.76	74.20	70.36
TiO_2	0.55	0.87	0.84	0.67	0.75	0.71	0.66	0.94	0.78	0.65	0.69
Al_2O_3	8.90	16.12	13.11	8.82	12.41	13.91	11.94	13.84	13.34	11.23	14.27
Fe_2O_3	2.22	3.90	5.19	3.07	4.66	6.48	3.45	5.81	4.83	3.58	3.50
MnO	0.074	0.070	0.015	0.012	0.016	0.071	0.026	0.095	0.074	0.072	0.15
MgO	0.86	1.58	1.53	0.87	1.39	1.86	1.00	2.03	2.03	1.45	1.34
CaO	1.78	1.29	0.94	0.84	1.09	1.19	0.92	1.36	1.15	1.28	2.47
K_2O	1.21	3.25	2.99	1.93	2.73	3.05	2.57	2.88	2.71	1.89	2.46
Na_2O	2.39	3.77	2.79	2.28	3.37	2.59	3.02	2.57	2.58	2.66	2.58
H_2O^+	0.45	0.49	NA	NA	NA	0.98	NA	0.72	0.36	1.39	1.35
P_2O_5	0.05	0.12	0.097	0.078	0.096	0.13	0.094	0.010	0.090	0.151	0.21
CO_2	0.81	0.29	NA	NA	NA	1.40	NA	0.48	0.62	0.34	0.27
Total	99.30	99.69	100.00	100.00	100.00	96.85	100.00	99.62	98.35		
As	600	7100	NA	NA	NA	26000	NA	150	1800	282	9
Au (ppb)	29	160	NA	NA	NA	92000	NA	10	945	NA	NA
Ba	150	375	365	245	350	340	375	340	280	446	503
Co	70	53	19	12	19	52	16	51	43	13	13
Cr	38	73	105	105	105	66	100	75	62	37	37
Cu	11	10	12	20	15	17	9	35	21	20	10
F	150	220	NA	NA	NA	240	NA	210	290	361	478
Li	24	32	NA	NA	NA	34	NA	24	46	36	61
Ni	9	17	17	11	17	25	16	32	22	26	26
Pb	24	40	142	156	16	236	24	42	190	NA	NA
Rb	44	90	NA	NA	NA	106	NA	94	98	30	42
Sr	133	200	135	103	135	156	130	136	140	196	13.4
V	42	101	61	45	55	78	57	98	86	NA	NA
Zn	47	151	440	320	81	274	86	151	300	50	97
Zr	219	196	NA	NA	NA	256	NA	196	217	278	176

[1] major element analyses in wt % and trace element analyses in ppm, except where indicated

[2] relative alteration intensity of selected greywacke lithologies from the Cochrane Hill gold deposit

[3] rock type: PQ = medium grained variably silicified greywacke
PF = fine grained variably silicified greywacke
the sample number (which appears in brackets) refers to the Cochrane Hill deposit

[4] average of 36 greywacke compositions for greenschist facies greywacke in Sherbrooke area

[5] average of 5 greywacke compositions for amphibolite facies greywacke in Sherbrooke area

NA = analysis not available

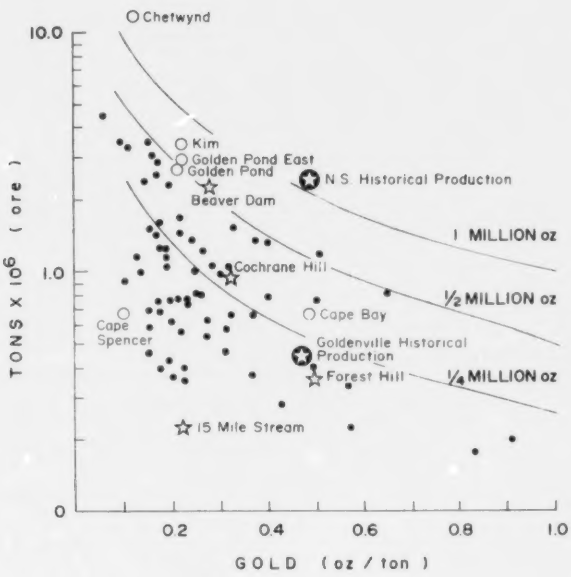

Figure 5. Tonnage and grade diagram (data from The Northern Miner magazine, September, 1986 and weekly publications of The Northern Miner) for the Nova Scotia deposits and some other recently discovered deposits in Canada. Note the favourable position of the Nova Scotian deposits compared to others in Canada. The Beaver Dam deposit is seen to contain approximately half of the recorded production of the gold in the Meguma Terrane, and further work is expected to increase the amount of contained gold at this deposit. Data for the Goldenville deposit represents the historical production.

the same deposit are shown. The veins which represent the end product of the alteration process have a pattern similar to the host rocks but their absolute REE contents are considerably reduced. The large gap between the veins and the host rocks is expected to represent the values of the silicified wall rocks. Thus, it should be relatively easy to detect the effects of alteration and at the same time determine what other elements were introduced during alteration processes (e.g. gold, arsenic).

IMPLICATIONS OF ALTERATION HALOES FOR THE GENESIS AND EXPLORATION OF MEGUMA GROUP GOLD DEPOSITS

Models proposed for the genesis of Meguma Group gold deposits have generally concentrated on the structural aspects of the veins and host rocks (Graves, 1976; Keppie, 1976; Graves and Zentilli, 1982; Mawer, 1985; Henderson and Henderson, 1986). The fluids which precipitated the quartz veins and associated mineralization were generally considered to have originated from some combination of pressure solution processes and dewatering of the Meguma Group during diagenesis and metamorphic reactions. In general, the systems were interpreted to operate on relatively local scales with lateral secretion playing an important role.

Detailed critical appraisal of the previously suggested models is not warranted at this stage, but the authors feel the following points are noteworthy:

. Fueten et al. (1986) show from mass balance calculations that the observed depletion of silica associated with pressure solution processes in cleaved zoned in psammitic lithologies at Harrigan Cove requires larger quantitites of fluid than could be locally derived by pressure solution processes.

. Bethke (1986) indicated from modelling that significant overpressures (i.e. hydraulic conditions) are unlikely to occur in a stratigraphy dominated by psammitic rocks such as in the Goldenville Formation which hosts most of the gold deposits. If this author is correct then the models of Graves and Zentilli (1982) and Henderson and Henderson (1986) deserve reconsideration.

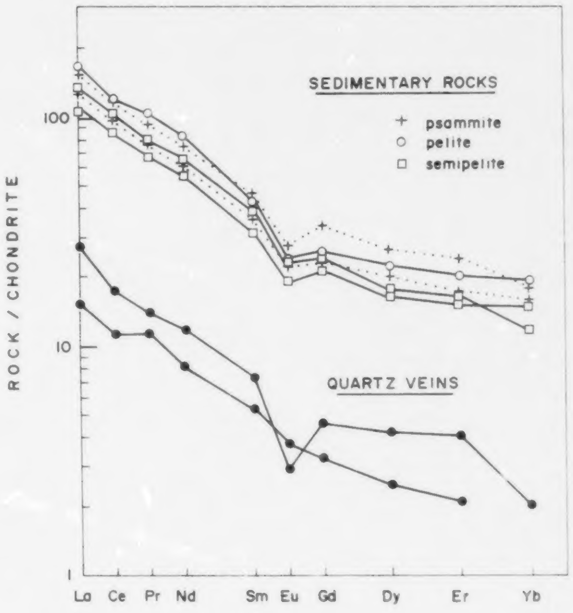

Figure 6. Chondrite-normalized REE diagram for sedimentary rocks and quartz veins from the Forest Hill deposit. See the text for a discussion of the patterns.

. Field observations (Smith and Kontak, 1986) suggest that many of the features observed in the gold districts are very late and, therefore, in many ways analagous to the situation envisaged for the Archean lode-gold deposits of the Canadian Shield (Colvine et al., 1984).

The large-scale alteration haloes discussed herein provide a partial solution to aspects which are not addressed by many of the models in the literature. These aspects include:

. large volumes of quartz in the mineralized districts,

. evidence of circulation of large quantities of water in host rocks (cf. Fueten et al., 1986),

. multiple vein injections in gold districts, and

. association of many gold deposits with structural breaks and(or) anticlinal hinges.

The authors envisage large volumes of fluid being channelled along deeply penetrating crustal-scale structures (e.g. Hutchinson et al., 1980) which focus the hydrothermal (auriferous?) fluids. A model similar to that of Kerrich and Allison (1978) for mineralization in the Yellowknife area may be applicable. In this situation, massive gold-bearing veins were precipitated during episodes of hydrothermal discharge caused by transient high fluid pressure. Vein geometries, textures of the quartz material and large alteration zones associated with the Meguma Group gold districts are consistent with such a model, thus eliminating the aforementioned problems. In addition, the amounts of gold (see Fig. 5) are similar to those of regions which have large alteration zones associated with the mineralization (e.g. Chetwynd deposit, Newfoundland, McKenzie, 1986).

Finally, the occurrence of large alteration haloes provide a viable exploration target as they are analagous to the large Mn haloes often found associated with massive sulphide deposits and phyllic alteration zones enveloping porphyry Cu-Mo deposits. These alteration zones not only provide a regional scale exploration target, but may also help to delineate auriferous zones not exposed at surface.

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RESULTS OF 1986 DIAMOND-DRILLING PROGRAM, YAVA BASE METAL DEPOSIT*

J. M. Patterson

INTRODUCTION

The Yava base metal deposit is situated in the Salmon River basin approximately 25 miles southwest of Sydney, Cape Breton (Fig. 1). A shallow diamond-drilling program was undertaken to investigate the extension of lead mineralization to the west of the area that was mined between 1979 and 1981. The program comprised 12 vertical drillholes totalling 1888 ft and was undertaken by the Drilling Division of the Nova Scotia Department of Mines and Energy (NSDME) during the period May 20 to July 9, 1986.

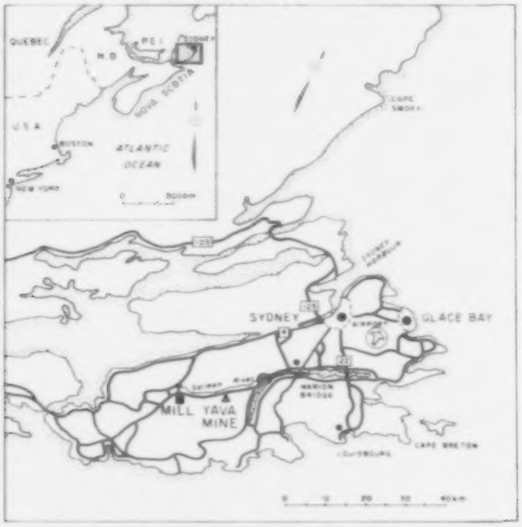

Figure 1. Location map

OBJECTIVES OF THE DRILL PROGRAM

Since assuming ownership of the Yava deposit, the Province (through the Mining Engineering Division of NSDME) has been documenting the potential of the deposit as a low grade open-pit lead mine. During this assessment certain gaps in information (due to the lack of drillhole data) became apparent, and a 3 phase drilling program was proposed to provide this missing information. Phase 1 of the program was to delineate the limits of the West Zone of the deposit. The West Zone was mined from 1979-1981 by Yava Mines Limited, and therefore provides the best controls to guide additional work. Further drilling will be undertaken to investigate potential extensions of mineralization in the Centre and East Zones, while a deeper hole will assess the downdip potential and possibility of zinc mineralization in the West Zone.

Bonham (1983) describes the history of the deposit together with the geology, controls to mineralization, mining and ore reserves.

DRILLING PROGRAM

During the summer of 1986 the Drilling Division of NSDME completed 12 vertical surface drillholes in the Yava West Zone (Fig. 1, Table 1). Figure 2 shows the location of these holes relative to previous drilling. The reader should note that the westerly extent of the mining operations of Yava Mine coincides approximately with line 35 West.

Table 2 displays the intersections in feet of major units cut in the holes, the footages sampled, the number of assays, the percentage of core assayed and the weighted averages for the sampled lengths.

All holes were logged, visible mineralization was sampled, and the half core sent for Pb, Zn and Ag assay.

Table 1. Diamond-drillhole co-ordinates and details

DDH#	WEST	NORTH	ELEVATION (ft)	TOTAL DEPTH (ft)
401	40+40	10+70	4979.3	195
402	40+60	12+72	4960.99	187
403	37+10	11+70	4958.24	207
404	39+10	10+80	4979.3	197
405	42+10	11+70	4971.37	157
406	44+15	12+80	4966.57	147
407	44+50	13+70	4950.98	97
408	42+15	13+90	4953.5	164
409	46+90	14+90	4952.69	125
410	47+10	13+00	4974.82	137
411	47+00	10+90	4986.86	101

RESULTS OF THE DRILLING PROGRAM

GEOLOGY

One of the major mineralization controls at the Yava deposit is basement topography, with the high grade mineralization preferentially occurring in depressions between basement topographic highs. This model has been used successfully as an exploration guide, and the recognition of such a depression west of the mined area was a factor in locating the recently completed drill program. Figure 3a shows the bedrock geology as interpreted from the recent drilling, and Figures 3b

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

and 3c display the geology on the 4900 and 4800 ft levels, respectively. This series of maps shows the locations of the basement topographic highs and indicates the occurrence of a rhyolite basement high very close to the surface at 45W/15N. The 4800 ft level plan shows a marked embayment filled with a thick rhyolite breccia on the southern margin of the basin. A marked linearity of geological contacts occurs in the vicinity of DDH 408 (Fig. 3c), which assayed 1.45% Zn over 3.8 ft.

Figure 4 displays serial longitudinal sections for the drilled area and reinforces the presence of the basement high to the west. Holes 407 (44W) and 409 (45W) demonstrate the usual low grade mineralization intersected in holes drilled on topographic highs.

Table 2. Yava west zone extension-1986 drilling program: geological and assay statistics

DDH#	OVERBURDEN	SST	WINDSOR GROUP	RHYOLITE BRECCIA	RHYOLITE TOTAL	DEPTH (ft)	ASSAY INTERSECTION (ft)		WIDTH (ft)	Pb (%)	Sn (%)	Ag (oz/t)
401	22.00	43.50	94.80	27.30	8.00	196.00	47.30	65.50	18.20	3.20	0.10	0.01
402	19.80	33.00	108.40	25.80	-	187.00	34.30	47.00	12.70	1.85	0.11	0.04
403	14.30	34.70	127.80	1.80	28.40	207.00	14.30	46.40	32.10	3.30	0.06	0.06
404	18.00	40.80	107.50	30.70	T	197.00	18.00	38.60	20.60	3.02	0.04	0.01
							41.90	49.50	7.60	2.74	0.04	0.01
405	20.20	40.70	75.10	5.00	16.00	157.00	20.20	38.20	18.00	1.95	0.30	0.01
							44.30	51.20	7.00	2.48	0.07	0.01
406	16.00	32.50	75.00	2.50	21.00	147.00	27.80	38.80	11.00	1.08	0.51	0.02
407	15.00	22.00	30.50	13.80	15.70	97.00	26.10	32.20	6.10	0.26	0.01	0.05
408	21.00	48.50	79.90	1.30	13.70	164.00	57.30	61.10	3.80	4.72	1.45	0.12
409	32.00	38.10	22.90	26.20	5.80	125.00	54.50	57.00	2.50	0.02	0.38	0.01
							60.20	70.10	9.90	1.15	0.10	0.07
410	25.00	33.60	59.30	2.80	16.30	137.00	31.90	46.00	14.10	1.42	0.38	0.01
411	26.40	10.60	53.00	2.00	9.00	101.00	26.40	37.00	10.60	1.73	0.03	0.03
412	25.30	19.40	88.10	28.20	12.00	173.00	25.30	35.60	10.30	2.16	0.08	0.01
							36.50	42.00	5.50	3.16	0.04	0.01

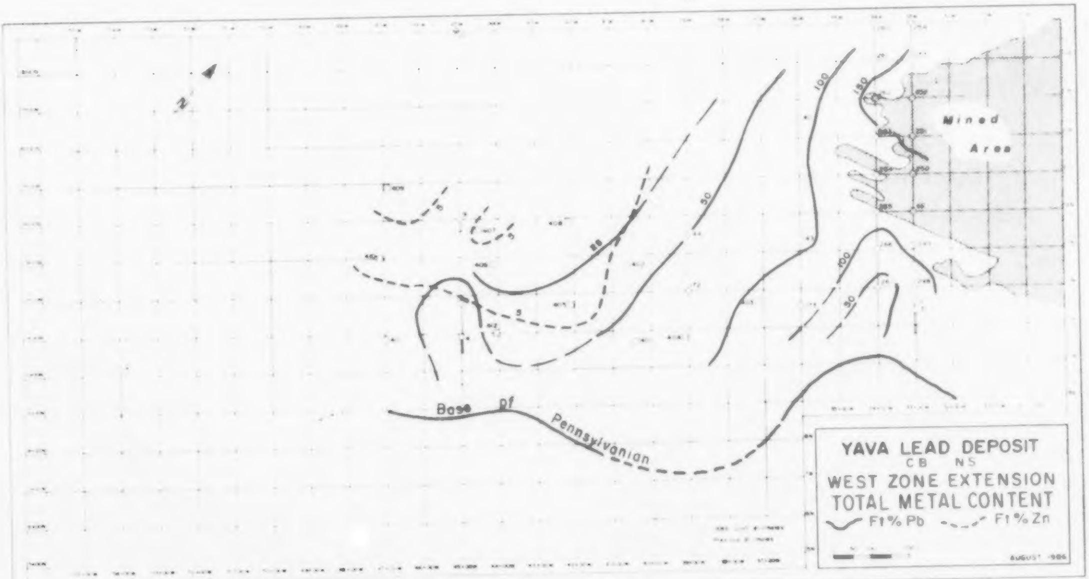

Figure 2. Total metal content

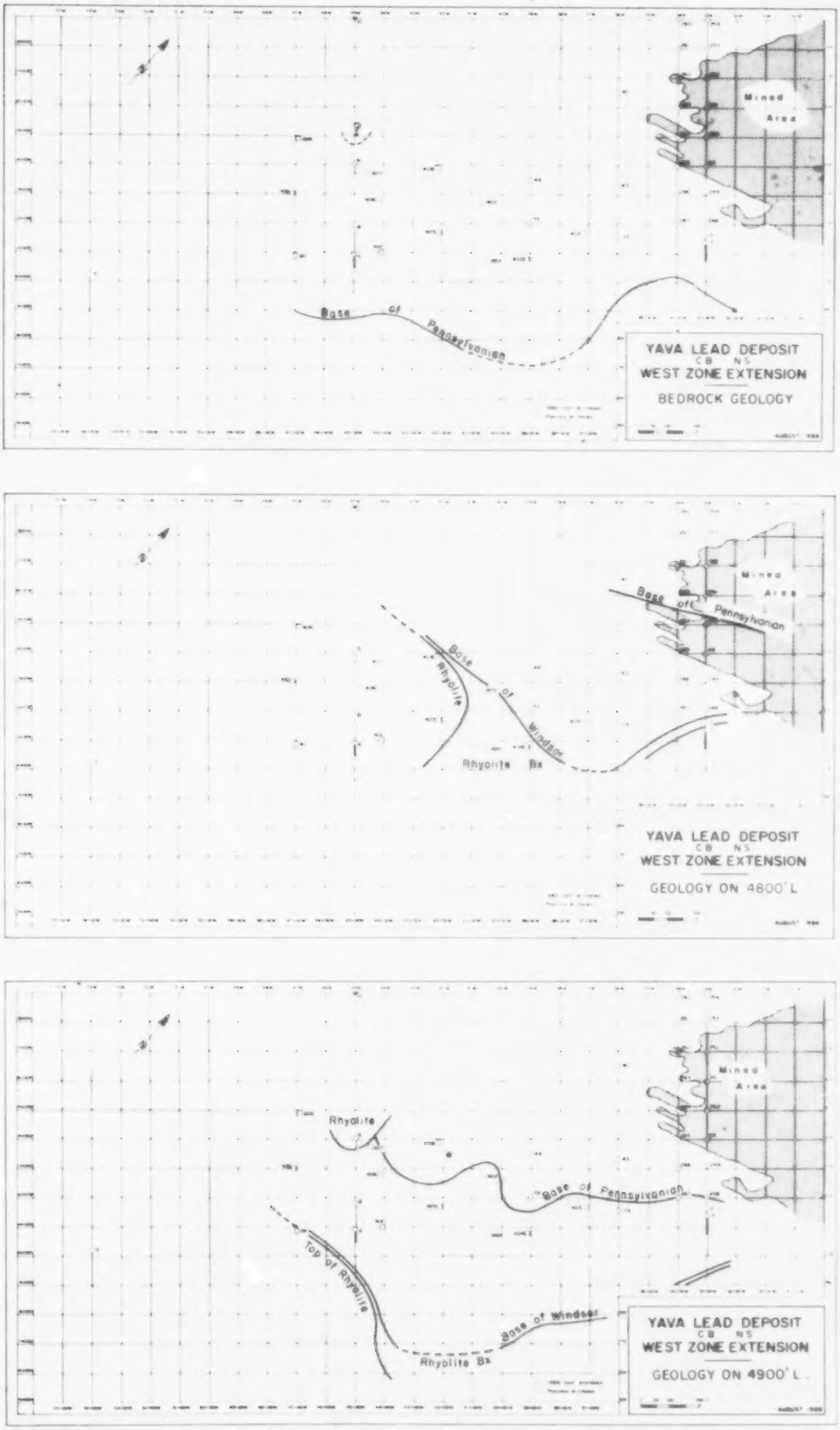
Mined Area
Base of Pennsylvanian
YAVA LEAD DEPOSIT
CB NS
WEST ZONE EXTENSION
BEDROCK GEOLOGY
Mined Area
Base of Pennsylvanian
Base of Windsor
Rhyolite
Rhyolite Bx
YAVA LEAD DEPOSIT
CB NS
WEST ZONE EXTENSION
GEOLOGY ON 4800' L
Mined Area
Rhyolite
Base of Pennsylvanian
Top of Rhyolite
Base of Windsor
Rhyolite Bx
YAVA LEAD DEPOSIT
CB NS
WEST ZONE EXTENSION
GEOLOGY ON 4900' L

Figure 3. Geology on bedrock, 4900 ft level and 4800 ft level

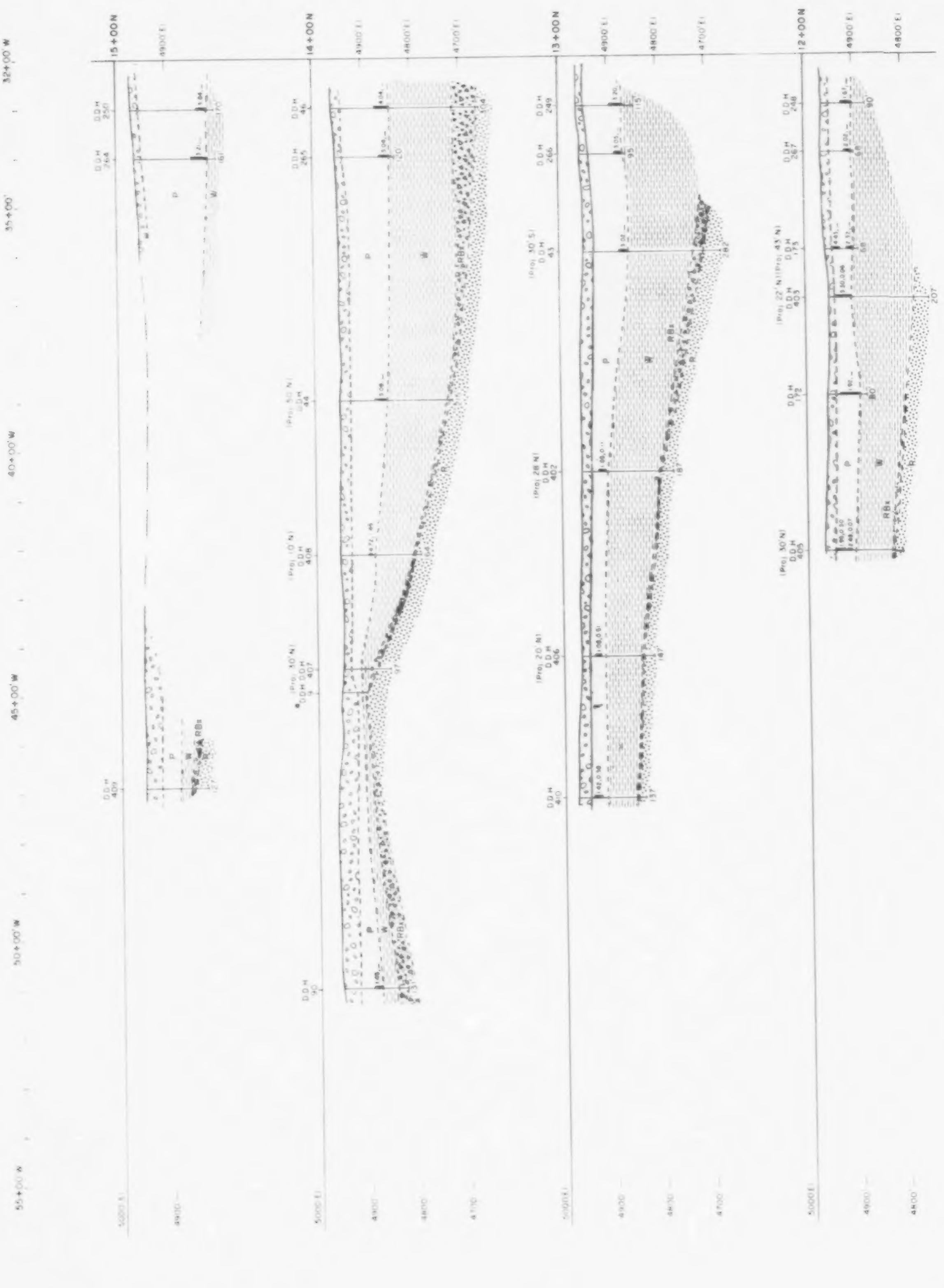
15+00N
14+00N
13+00N
12+00N
32+00 W
35+00
40+00 W
45+00 W
50+00 W
55+00 W
5000 El
4900
4800
4700
D.D.H.
P
W
RBs
R

Figure 4. Serial longitudinal sections

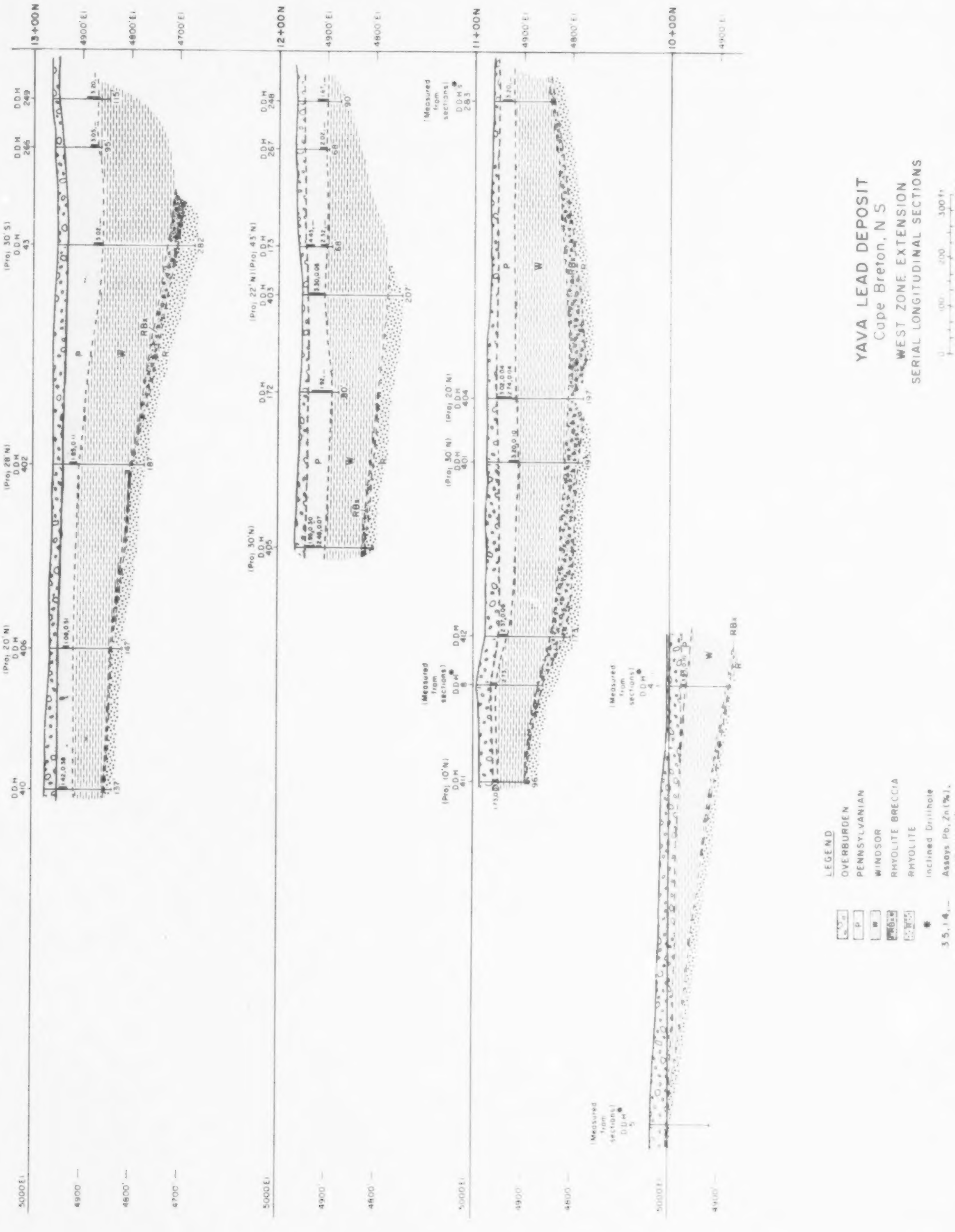
YAVA LEAD DEPOSIT
Cape Breton, N.S.
WEST ZONE EXTENSION
SERIAL LONGITUDINAL SECTIONS
13+00N
12+00N
11+00N
10+00N
5000'El
4900'El
4800'El
4700'El
LEGEND
OVERBURDEN
PENNSYLVANIAN
WINDSOR
RHYOLITE BRECCIA
RHYOLITE
Inclined Drillhole
Assays Pb, Zn (%), not assayed
P
W
RBx
R

Figure 4. Continued

METAL DISTRIBUTION

Data presented in Table 2 and Figure 2 indicate that significant values are present in areas open updip and downdip. The 3.8 ft intersection of 4.72% Pb and 1.45% Zn in DDH 408 is of special note. Support for this intersection is shown in Figure 2 where a significant relative enrichment in zinc remains open to the north. The Ft% lead contours (Fig. 2) indicate that there is tonnage potential for approximately 250 ft south of the most southerly hole on 11N. The host Pennsylvanian sandstone thins to the south, and therefore holes here will not be deep and the tonnage potential will be limited.

GEOPHYSICS

Ten of the 1986 drillholes were geophysically logged by the Geological Survey of Canada (GSC). This work is experimental and involves the measurement of 10 parameters. Preliminary results from the logging indicate that some of the techniques used will assist future drillhole target selection. The results of these investigations will be released by the GSC, beginning with Current Research in January 1987.

FUTURE WORK

The recent drilling has extended the lead mineralization to the west and the south, and has indicated a relative downdip enrichment in zinc content. This situation is similar to that at the Laisvall mine in Sweden where a sandstone-hosted lead deposit passes downdip to a zinc-rich deposit (Rickard et al., 1979).

Future drilling should consider this aspect and, in addition, define the updip extent of the shallow mineralization.

It is recommended that 13 holes, totalling 1900 ft, be drilled to test the zinc potential immediately north of the recently drilled area. A lower priority is the continued investigation of the shallow updip lead potential and 8 holes comprising 1300 ft are recommended to complete this program.

The potential for lead and zinc much further downdip and at higher stratigraphic levels (cf. Laisvall) will be investigated by a deeper hole with estimated total depth of 1400 ft.

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THE EAST KEMPTVILLE LEUCOGRANITE: A POSSIBLE MID-CARBONIFEROUS TOPAZ GRANITE*

D. J. Kontak

INTRODUCTION

The East Kemptville tin-polymetallic base metal deposit (Richardson et al., 1982; Richardson, 1983; Chatterjee et al., 1985) located in Yarmouth County, southwest Nova Scotia (Fig. 1), is currently the only primary producer of tin in North America. Originally discovered by Shell Canada Resources Limited in 1978, it was subsequently purchased by Rio Algom Limited (20%) and a consortium of banks in 1982. Production (ca. 9000 tons of ore/day) commenced in October 1985. In December 1986, Rio Algom Limited withdrew from the project and a new company, the East Kemptville Tin Limited headed by Bank of America, was established. However mining of the

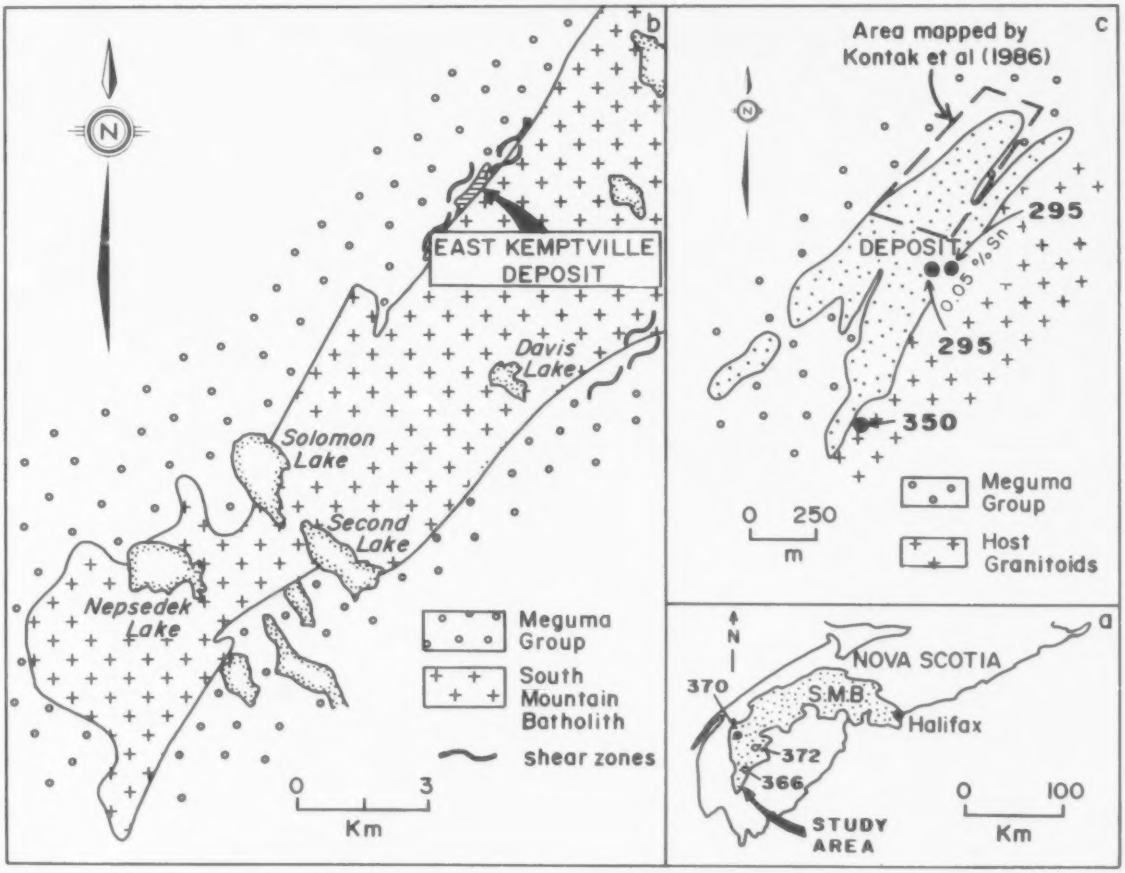
b
N
EAST KEMPTVILLE DEPOSIT
Davis Lake
Solomon Lake
Second Lake
Nepsedek Lake
Meguma Group
South Mountain Batholith
shear zones
0
3
Km
c
Area mapped by Kontak et al (1986)
N
295
DEPOSIT
0.05 % Sn
295
350
0
250
m
Meguma Group
Host Granitoids
a
N
NOVA SCOTIA
S.M.B.
Halifax
370
372
366
STUDY AREA
0
100
Km

Figure 1. Location map and regional geological setting of the East Kemptville tin deposit in the South Mountain Batholith (modified after Richard et al., 1982 and Richardson, 1985b) with the location of that part of the deposit mapped during July-August 1986 (Kontak et al., 1986). The radiometric ages indicated in Figures 1a and 1c are from Reynolds et al. 1981 and Zentilli and Reynolds (1985), respectively, and represent the results of $^{40}Ar/^{39}Ar$ dating of micas.

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

deposit is still managed by Rio Algom Limited. Reserves for the deposit are 56 million tons of 0.165 % Sn and although base metal (i.e. Cu, Zn) mineralization occurs, tin is the only metal currently recovered.

The deposit, approximately 1500 m x 500 m x 100 m in dimension (determined using cutoff of 0.05% Sn; Fig. 1), is localized at the contact of the Devono-Carboniferous South Mountain Batholith (SMB) and quartzites of the Lower Paleozoic Meguma Group (Goldenville Formation). Previous workers (e.g. Richardson et al., 1982; Richardson, 1983, 1985a, 1985b; Chatterjee et al., 1985) have postulated that the deposit formed by fractionation of a granodiorite parent magma to a highly evolved, volatile- and metal-rich late stage leucogranite which, as a result of its shallow level of emplacement beneath a flat-lying impermeable quartzite capping rock, produced extensive zones of mineralized greisens within the leucogranite. Most of the previous work suffered from the paucity of outcrop in the immediate vicinity of the deposit and, consequently, several inferences were made with respect to magmatic evolution without well established field relationships or geochronological control.

Recent field studies conducted at the East Kemptville deposit (Kontak et al., 1986) have revealed some important new geological features which must be considered in any discussion of the origin of the host rock leucogranite, herein referred to as the "East Kemptville Leucogranite" (EKL). In addition, recent chemical analyses have been obtained on relatively pristine granites from the deposit area which indicate markedly different compositions than other areas in the South Mountain Batholith.

The purpose of this paper is to use this new information to resolve the origin of the mineralized leucogranite by examining its possible age, magmatic evolution (i.e. generation and subsequent emplacement and crystallization), regional geological setting and comparison to other felsic rock suites. Many of the features displayed by the granite are compatible with those suggested to be indicative of topaz rhyolites/granites (Burt et al., 1982; Christiansen et al., 1983, 1984; Pichivant and Manning, 1984) or A-type granites (Loiselle and Wones, 1979; Collins et al., 1982; White and Chappell, 1983). Such felsic igneous rocks are generally characteristic of a particular tectonic setting and are frequently associated with lithophile element mineral deposits. Thus, the recognition of such rock types are important for exploration of additional tin mineralization in this part of southwestern Nova Scotia.

REGIONAL GEOLOGICAL SETTING AND INFERRED AGE OF THE EKL

The East Kemptville deposit is hosted by a small protrusion of granite (EKL) which intrudes metasediments of the Goldenville Formation, the oldest member of the Lower Paleozoic Meguma Group (Fig. 1). The granitoid rocks of the mine area are part of the Davis Lake Complex, a term originally proposed by McAuslan et al. (1980) for the granitic body underlying the Davis Lake area (Fig. 1b). Richardson (1983, 1985a, 1985b) used the term in a more regional sense to include all granitoid rocks forming the southwest part of the SMB. At present there is no well defined definition which describes the distribution and features of this intrusive complex. In this paper the term is used merely in reference to the majority of felsic intrusive rocks comprising the southwest part of the SMB (see inset of Fig. 1b).

The granitoid rocks forming the southwest part of the SMB are post-tectonic, peraluminous, generally medium- to coarse-grained, biotite granodiorites and monzogranites, and 2-mica granites which are inferred to represent a co-magmatic suite (Richardson, 1983, 1985b). Late stage alteration has resulted in extensive zones of silicification and albitization along the northwest margin of the Davis Lake Complex (Chatterjee et al., 1985). Withing the granitoid rocks there occur northeast trending zones of intense deformation (mylonites). These zones are recognized along the southern and northern contacts of the SMB (Fig. 1b; Smith, 1985; Kontak et al., 1986), and at other localities within the SMB (J. D. Keppie, personal communication, 1986). The age of the granitoid rocks comprising this part of the SMB are inferred to be approximately 370 Ma old based on $^{40}Ar/^{39}Ar$ mica dates (Fig. 1a; Reynolds et al., 1981). Zentilli and Reynolds (1985) have reported a wide range in $^{40}Ar/^{39}Ar$ muscovite ages at the East Kemptville deposit, (Fig. 1c). These authors obtained a discordant age spectra for a sample immediately outside the ore zone which indicated a minimum age of 350 Ma for the host granitoid. In contrast, two greisen samples from the deposit gave plateau ages of 295 Ma. The meaningfulness of the latter age is considered suspect since the rocks in the deposit area were deformed to varying degrees (Kontak et al., 1986). Thus, the 295 Ma age may represent an overprinting related to the deformation, rather than the time of hydrothermal alteration related to mineralization.

Thus, there remains at present no reliable chronological data for the host granitoid at the East Kemptville deposit. The best estimate for the age of the EKL is inferred to be >295 Ma and <350 Ma. However, Rb-Sr and K-Ar dating (Lowdon et al., 1963; Fairbairn et al., 1960, 1964; Reynolds et al., 1981) has indicated a distinct period of younger granitoid magmatism (ca. 250-300 Ma) as represented by the Wedgeport Pluton. This has recently been confirmed by a combined whole rock Rb-Sr and U-Pb zircon dating project by Keppie et al. (1983). These authors obtained essentially similar ages of 313 Ma using both techniques.

FIELD STUDIES AND PETROGRAPHY OF THE LEUCOGRANITE

The EKL was examined during the course of mapping the East Kemptville deposit (Fig. 1c: Kontak et al., 1986). Previous work at the deposit indicated that most of the host rock was extensively altered due to the hydrothermal activity which attended the mineralizing event. However, during this investigation it became apparent that a large part of the area is, instead, underlain by relatively fresh* leucogranite (Fig. 2).

The EKL is a relatively homogeneous, fine- to medium-grained, muscovite-bearing (1-3%) leucomonzogranite with a uniform proportion of quartz (~42%), plagioclase (~33%) and K-feldspar (~25%), as determined by point counting stained rock slabs (Fig. 3). Distinct phenocrystic phases, a common feature throughout a large part of the SMB, are notably lacking in the EKL. Although textural variations were observed, it was not possible to map distinct phases of the granite and no intrusive contacts were noted. Thus, the body may represent either a single intrusive phase or multiple injections of texturally different granite. At present, the first alternative is preferred with the different textural varieties interpreted to reflect the influences of variations in certain physical and chemical parameters (i.e. cooling rate, volatile content). Some felsic dyke rocks do occur, but they are generally narrow (< 10-20 cm width) and can only be traced for short distances. There is a conspicuous absence of miarolitic cavities, and pegmatites were observed in two isolated localities. Thus, all indications suggest that the melt was undersaturated with respect to a volatile phase during most, if not all, of its crystallization history.

Petrographic examination of EKL reveals a simple mineralogy consisting of quartz, plagioclase, K-feldspar, muscovite, topaz and apatite as the important, primary constituents. Plagioclase is nearly pure albite in compositon (confirmed by electron microprobe analysis) and varies from very fresh in appearance to variably saussuricitized. K-feldspar occurs as orthoclase (dominant) and microcline with a variety of perthite exsolution lamellae (i.e. string, braid, patch). In some cases, homogeneous, unexsolved patches of orthoclase occur in either coarsely perthitic orthoclase or microcline. Thus, the presence of a highly variable assemblage of alkali feldspar polymorphs indicates a complex postmagmatic cooling history (e.g. Parsons and Brown, 1984). Muscovite occurs as inclusion-free, isolated, euhedral to subhedral grains of probable primary magmatic origin as they appear to be in equilibrium with all the other major silicate phases. Topaz occurs mostly as subhedral grains (rarely euhedral) of similar grain size as the other silicate phases and sometimes occurs as inclusions in plagioclase and(or) muscovite. It is inclusion-free, rarely has a reaction rim, and commonly has good crystallographic contacts with the adjacent silicate phases. Thus, the textural features of topaz are consistent with a magmatic origin. Apatite occurs as an intracrystalline, coarse, euhedral to subhedral phase. Additional minerals, all of questionable origin, include trace amounts of andalusite, fine grained white mica, sulphides, fluorite and cassiterite. To date no biotite or chlorite, its alteration product, has been observed.

Within the deposit area the EKL is heterogeneously deformed with a wide range of fabrics developed. However, in general there is a dominant northeast-southwest trending spaced fracture cleavage present which locally gives way to well developed C-S fabrics and, where deformation is most intense, mylonitic zones approximately 0.5-1.5 m wide.

CHEMICAL ANALYSES

To date 13 samples (collected from within the map area shown in Fig. 2 and also in other parts of the deposit) of the EKL have been analyzed for major and trace element chemistry. The major element chemistry of the EKL is very consistent (Table 1), as is expected from the limited variation in the modal abundances of the major silicate phases. The data are characterized by high silica (72-75 wt % SiO_2) and alumina (14.0-15.0 wt % Al_2O_3) contents, and phosphorous (0.45-0.99 wt % P_2O_5) is anomalously enriched for felsic igneous rocks in general (Watson and Capobianco, 1981), although some late stage leucogranites in the SMB are similarly enriched (Kontak, unpublished data). The peraluminous index (A/CNK) for the EKL is 1.25-1.30, indicating that it is strongly peraluminous. The alkali contents are not unusual and are consistent with magmatic values (cf. Hughes, 1973). However, the K_2O/Na_2O ratio (1.0-1.05) is abnormally low compared to the average composition of granitic rocks (ratio of 1.1) of LeMaitre (1976), or the averages for monzogranites of the SMB (1.37: Clarke et al., 1985) and the Davis Lake Complex (1.19: Chatterjee et al., 1983). Although some of the Na may be in part attributed to metasomatic processes (e.g. Richardson, 1983), the F-rich nature of felsic rocks change the minimum in the quartz-feldspar system such that more sodic compositions are favoured (Manning, 1981). Thus, low K_2O/Na_2O ratio may be signatures of magmatic processes. The CaO contents (0.4-0.6 wt % CaO) are similar to those reported for other high-silica granites or rhyolites, and low abundances of Mn (<0.1 wt % MnO), Ti (<0.08 wt % TiO_2) and Mg (<0.07 wt % MgO) are consistent with the highly evolved nature of the EKL.

The trace element contents of the EKL are in many cases anomalously high for Rb, Li, F, Nb, U, Y, Sn and Ga compared to the low-calcium granites (e.g. Turekian and Wedepohl, 1961; average analysis given in Table 1) and, instead, compare more favourably to values reported for felsic igneous rocks associated with lithophile element mineralization (e.g. Tischendorf, 1977; Taylor, 1979). The EKL data are compared to some specialized suites of felsic composition in Table 1, as summarized from the literature. The following is a brief summary of the general

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*The term fresh, although perhaps controversial when used to describe a specialized granite (e.g. Pollard and Taylor, 1986), is used herein to refer to rocks that (1) maintain a hypidiomorphic granular texture, (2) have primary, fresh alkali feldspar and plagioclase of magmatic composition, and (3) are devoid of fractures along which are formed secondary minerals related to mineralization. Although a certain amount of late stage alteration is present, it is no greater than the amount characteristic of most leucogranitic granites unrelated to mineralization.

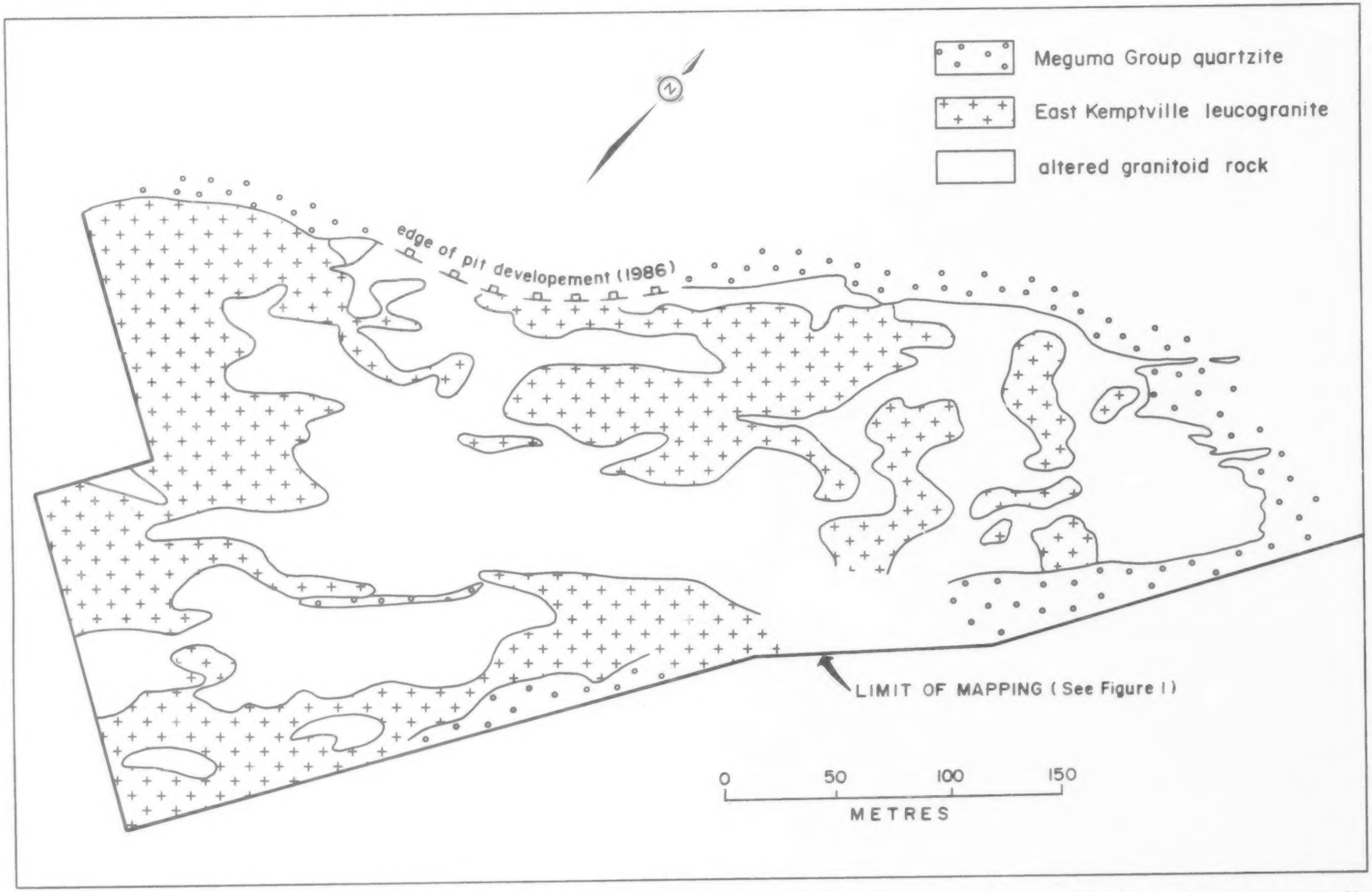
Meguma Group quartzite
East Kemptville leucogranite
altered granitoid rock
N
edge of pit developement (1986)
LIMIT OF MAPPING (See Figure I)
0
50
100
150
METRES

Figure 2. Outline of the mapped area at the East Kemptville deposit. The map area underlain by the EKL is indicated with the remainder consisting of variably altered granitoid lithologies (Kontak et al., 1986).

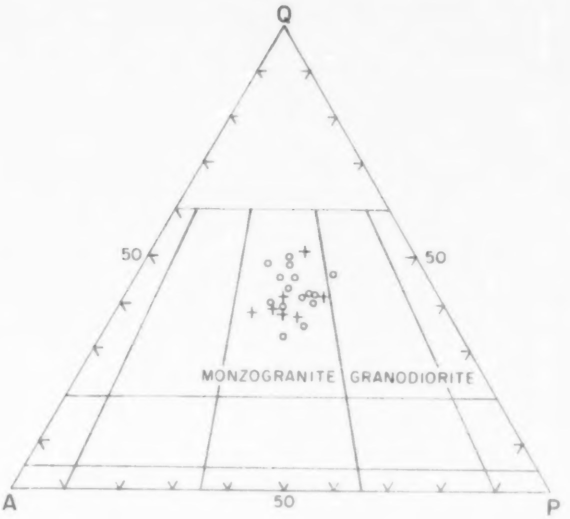

Figure 3. Modal analyses of the East Kemptville leucogranite (EKL) plotted in the quartz- plagioclase- alkali feldspar (QAP) diagram of Strekeisen (1976).

features of the anomalous trace element character of the EKL suite; a more thorough documentation will be presented elsewhere. In this discussion, the chemistry of the EKL is compared to that obtained for a biotite monzogranite (BMG) which occurs as sparce outcrops and abundant erratics in the vicinity of the deposit. The actual field relationships between this phase and the EKL are not presently known, but spatially it is the nearest rock to the EKL which is obviously of different character. Richardson (1983, 1985b) suggests that this unit may represent a less differentiated parent to the EKL. The validity of this suggestion will be addressed when discussing the genesis of the EKL. In the following section, the EKL data are also compared to unpublished data obtained on a variety of granitoid rocks from the SMB. This comparison is used to contrast the chemistry of the EKL with that of the SMB granitoids.

The Rb content of the EKL rocks (800-1100 ppm) exceeds all but the most evolved rocks in the SMB, these being small leucogranites associated with pegmatites such as at New Ross or similar areas (Fig. 4; Charest et al., 1985). In addition, the values are more similar to those reported for such highly evolved suites as the Macusani volcanics (Pichavant et al., in press; Kontak et al., 1984) and ongonites (Table 1; hichavant and Manning, 1984). Using Rb as an index of fractionation, the EKL rocks are compared to typical SMB values for Zr, Ba and Sr (Fig. 4). Although the EKL rocks have comparable Zr and Ba values for the Rb content, Sr is anomously enriched especially considering the low Ba values and general compatability of Ba and Sr. Note also that the BMG has lower Sr values than the EKL despite the lower Rb content of the latter and that the average Rb and Sr contents for the Davis Lake leucogranite are markedly different than the EKL.

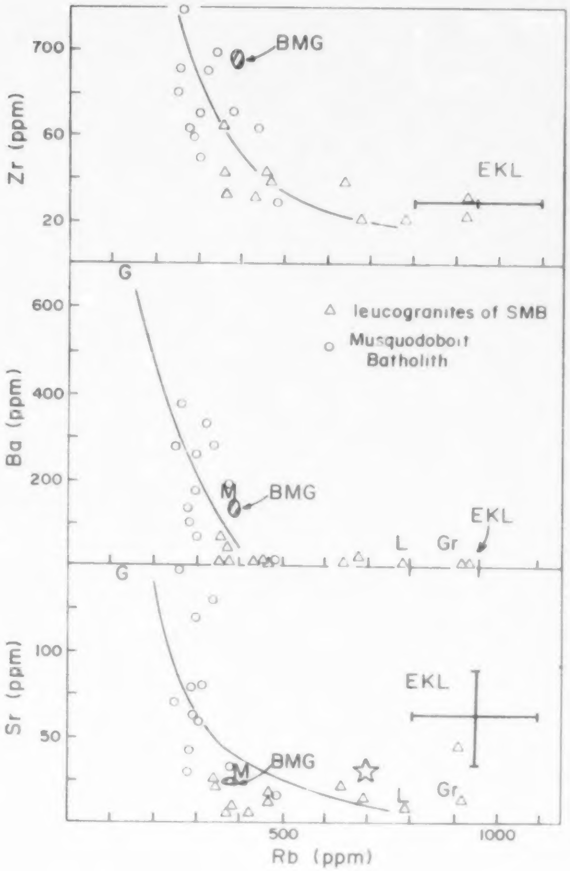

Figure 4. Plot of Zr, Ba and Sr versus Rb for leucogranite is indicated by the star (data from Chatterjee et al., 1983). rocks of the East Kemptville leucogranite (EKL; range is indicated by the crossed lines) and the biotite monzogranite (BMG). Data for monzogranites and leucogranites of the SMB is from Kontak (unpublished data) and for the Musquodoboit Batholith from MacDonald and Clarke (1986) and unpublished data of Kontak. Average values for the granodiorites (G), monzogranites (M), leucomonzongranites (L) and greisens (Gr) of the SMB are from Clarke et al. (1985), and the average composition of the Davis Lake

Table 1. Representative analyses of specialized felsic igneous rocks (generally volatite-rich) compared to the East Kemptville leucogranite (EKL; sample 11)

MAJOR/ TRACE ELEMENT*	1	2	3	4	5	6	7	8	9	10	11
SiO_2	75.3	76.6	76.07	75.3	73.43	72.26	76.86	73.60	75.80	69.58	73.06
TiO_2	0.07	0.07	0.08	0.03	0.13	0.04	0.03	0.33	0.13	-	0.02
Al_2O_3	12.7	12.8	12.31	13.5	14.35	18.83	11.99	12.69	12.65	16.60	14.62
Fe_2O_3	1.01	0.98	1.72	1.3	1.25	0.75	1.15	2.80	1.72	0.65	1.25
MnO	0.08	0.06	0.02	0.08	0.04	0.06	0.03	0.06	0.04	0.22	0.06
MgO	0.07	0.06	0.05	0.09	0.20	0.02	0.10	0.33	0.18	0.13	0.03
CaO	0.70	0.67	0.69	0.52	0.50	0.22	0.33	1.09	0.67	0.52	0.52
M_2O	3.85	3.98	3.03	3.10	3.37	4.14	3.52	3.34	3.41	5.87	3.68
K_2O	4.86	4.62	4.86	4.86	4.54	3.66	4.98	4.51	4.08	3.53	3.81
P_2O_5	0.00	0.00	0.01	0.01	0.36	0.53	0.01	0.09	0.11	0.09	0.57
F	-	-	-	7800	1700	13330	2016	-	3318	20500	11500
B	-	-	-	-	96	1900	-	-	-	-	<10
Li	-	-	-	349	789	3450	87	-	146	-	360
Rb	605	533	485	1136	549	1170	556	199	700	2895	965
Sn	5	15	29	20	88	1.6	11	105	31	-	57
Ba	-	-	37	90	246	<10	56	605	73	-	ND
Zn	120	110	159	156	72	39	154	342	-	-	28
Nb	73	60	87	85	20	44	76	22	-	-	32
Ga	40	35	-	-	-	42	21	21	-	-	35
U	-	-	-	30	8	20	14	5	23	-	25
Th	-	-	39	47	9	1	65	23	25	-	5
Y	46	93	179	30	9	5	11	76	-	-	38

1. topaz rhyolite, Spoor Mountain, Utah (#F-37; Christiansen et al., 1984)
2. topaz rhyolite, Thomas Range, Utah (#V-59; Christiansen et al., 1984)
3. Harvey volcanic suite, New Brunswick (#3B, average of 7; Payette and Martin, 1986)
4. porphyritic granite, Mount Pleasant, New Brunswick (#82-50; Kooiman et al., 1986)
5. Macusani vokanics, Peru (MH-3 tuff; Pichavant et al., in press)
6. Macusani glass, Peru (JV-1; Pichavant et al., in press)
7. Ackley granite, Newfoundland (Unit 14b, average of 9; Tuach et al., 1986)
8. average Australian A-type granite (White and Chappell, 1983)
9. Davis Lake leucogranite (average of 94; Chatterjee et al., 1983)
10. Ongonite, Mongolia (average of 10; Pichavant and Manning, 1984)
11. average East Kemptville leucogranite (n=13)

* major element analysis in %; trace element analyses in ppm

ND = not detected

The U and Th contents (Fig. 5) of the EKL are uniform at ~25 ± 5 ppm and 5-6 ppm, respectively. The U content is similar to that of the Davis Lake Complex, but the EKL is depleted in Th (Chatterjee et al., 1983). Compared to the general trend established for the SMB by Chatterjee and Muecke (1982), U is enriched compared to the average leucogranite (~8-10 ppm U), although the Th values are comparable. Thus, the U-Th systematics for the EKL and BMG are different for the two previously establised trends for granitoid suites of the area.

The Sn content of the EKL is highly variable and, as noted above, cassiterite does occur as

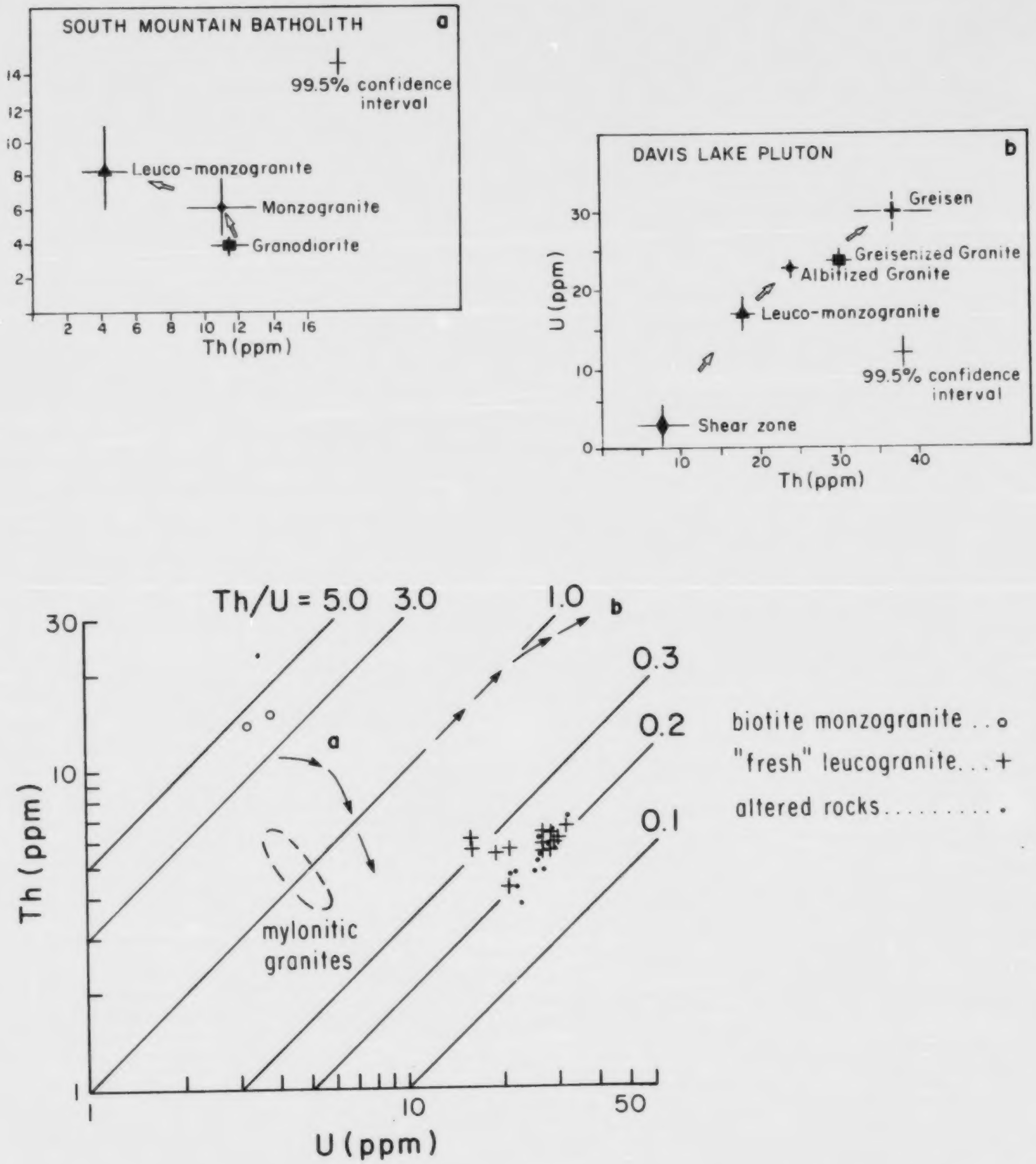

Figure 5. Log scale plot of U versus Th for fresh and altered rocks of the East Kemptville leucogranite (EKL) and the biotite monzogranite. The trend is compared to the U-Th data for the South Mountain Batholith (SMB) and Davis Lake pluton defined by Chatterjee and Muecke (1982). The mylonitic granites represent samples of intensely deformed EKL.

a discrete phase in the EKL. The values range from 73 to 422 ppm and there is a poor correlation between Sn and elements such as F. All the samples selected for analyses were chosen because of their relatively "fresh" appearance and, therefore, the high Sn content raises concern with respect to the origin of such high stanniferous values in these rocks. The possibility of primary magmatic tin cannot be excluded. Although not enriched to the same degree as tin, tungsten values of 10-44 ppm are certainly anomalous compared to those expected in normal, low-Ca granites or the average leucomonzogranites of the SMB (~5-10 ppm; Kontak, unpublised data).

The EKL is perhaps most anomalous with respect to its enrichment in volatile elements, most notably F. Although B is very low in these rocks (i.e. <10 ppm), Li ranges from 170-750 ppm and F values are 0.46 to 2.37 wt %. These compare with 40 ppm Li in the average low-Ca granite (Turekian and Wedepohl, 1961) and 800 ppm F in normal granites (Bailey, 1977). Compared to the SMB suites, the only rocks which show similar enrichment in F are very evolved leucogranites related to mineralization as at Gaspereau Lake (U; 3000 to 4700 ppm F) and Long Lake (W-Mo; 3100 ppm F), or islolated greisen occurrences (7000 ppm F; Clarke et al., 1985). In terms of the elemental abundances of Li, F and Rb the EKL has similar values as topaz granite and rhyolite (Figs. 6b and 6c) associated with lithophile element mineralization (Taylor et al., 1985). The covariation of Rb and Zr is also similar to that of F-rich felsic igneous suites in general (Fig. 6a), and in fact, the extremely evolved nature of the EKL rocks is demonstrated here by its comparative depletion of Zr.

In Figure 7, the average trace element values for the EKL are compared to the abundance of these elements in a variety of granite types compiled by Pearce et al. (1984). The EKL compares most favourably with the syn- or post-collision granites that are characterized by enrichment of large ion lithophile elements and depletion of high field strength elements. The extreme depletion of Ba and Zr in the EKL is again emphasized in this diagram. This diagram also serves to illustrate that the normalized trends of these elements in the EKL are similar to magmatic values in other granite suites and therefore, it is considered reasonable to assume that for these and other elements in the EKL magmatic values may also be represented. This point is also illustrated by comparing data from a variety of granite types in the SMB with the EKL data in a plot of Y versus Nb (Fig. 8). The SMB data suggest two trends are possible, one being magmatic and the other some combination of magmatic and hydrothermal processes (orthomagmatic?). The EKL data fall on the magmatic trend and compare favourably with data compiled from the literature for topaz rhyolites of the southwest United States, the evolved units of the Ackley Granite, Newfoundland, and the F-rich Harvey Volcanic suite, New Brunswick. Considering the typical magmatic values for most of the incompatible elements and reasonable major element chemistry, a similar magmatic origin is argued for the remaining elements (i.e. F, Li, Sn, W, etc.).

Finally, the EKL data are compared to the field defined by Collins et al. (1982) for the A-type granites of the Lachlan Fold Belt of southeast Australia in their Ga versus Al_2O_3 plot (Fig. 9). The EKL is enriched in Al and Ga compared to the Australian granitoids, however, similar Ga enrichment is observed in rocks of the SMB and topaz rhyolites of the southwest United States. It appears from the SMB and topaz rhyolite data that the Ga enrichment may be a product of either magmatic fractionation (ex. SMB, Nova Scotia and the Ackley Granite, Newfoundland; Tuach et al., 1986) or reflect a primary source rock enrichment.

DISCUSSION

The field relationships, petrography and chemical features of the EKL outlined in the previous sections indicate that it is not a typical end member of the suite of rocks comprising the SMB. In particular, it is anomalous in the presence of topaz as a probable magmatic phase and its extreme enrichment in many of the trace elements (F, Li, Rb, Sn, W, Ga) and P. In addition, the EKL does not have the same U-Th systematics as presently documented for the SMB rocks, and it is also enriched in Sr for its relative degree of fractionation (measured as function of Rb content). Although many of the elemental enrichments observed in the EKL are similarly attained in some leucogranites of the SMB (e.g. New Ross area; Charest et al., 1985), these are the result of fractionation processes operating on a local scale and can be related to less evolved monzogranites in the immediate area. In contrast, the EKL is a relatively large, homogeneous, fine- to medium-grained, rare metal and volatile-rich granitoid. Many of the features outlined above are consistent with those suggested for topaz granites (Pichavant and Manning, 1984) and topaz rhyolites (Christiansen et al., 1983, 1984; Burt et al., 1982), and it is suggested that the EKL may represent a similar rock type.

Consideration of the EKL as a topaz-type granite allows many of the above features to be explained by analogy with other occurrences of such rocks. The volatile-rich (particularly F, Li and B) nature of these melts permits unusual enrichment of rare elements as the volatile constituents modify the structure of the melts (i.e. depolymerization). For example, Pichavant et al. (in press) show by analysis of Macusani glass from southern Peru (a quenched, volatile and rare-element rich, peraluminous melt) that considerable enrichment occurs in melts of these compositions. In addition to the data in Table 1 (analyses 5 and 6), the following results are also provided: 155-203 ppm Sn, 59-73 ppm W, 27 ppm Ta and 516-571 ppm Cs. Such enrichments of elements in these specialized melts indicate that upon crystallization, phases such as cassiterite, topaz, fluorite, phosphates and other rare or exotic minerals must form. Therefore, the presence of cassiterite in the EKL rocks for example, does not necessarily imply that it has a postmagmatic origin and formed as a result of interaction with late stage hydrothermal fluids. As shown above, many of the chemical features of the EKL are consistent with the elemental abundances reflecting magmatic values. If anything, the contents should be considered as minimum values since most of the elements of interest would be preferentially partitioned in favour of an exsolved fluid phase. In the same way as the volatile-rich nature of the melt

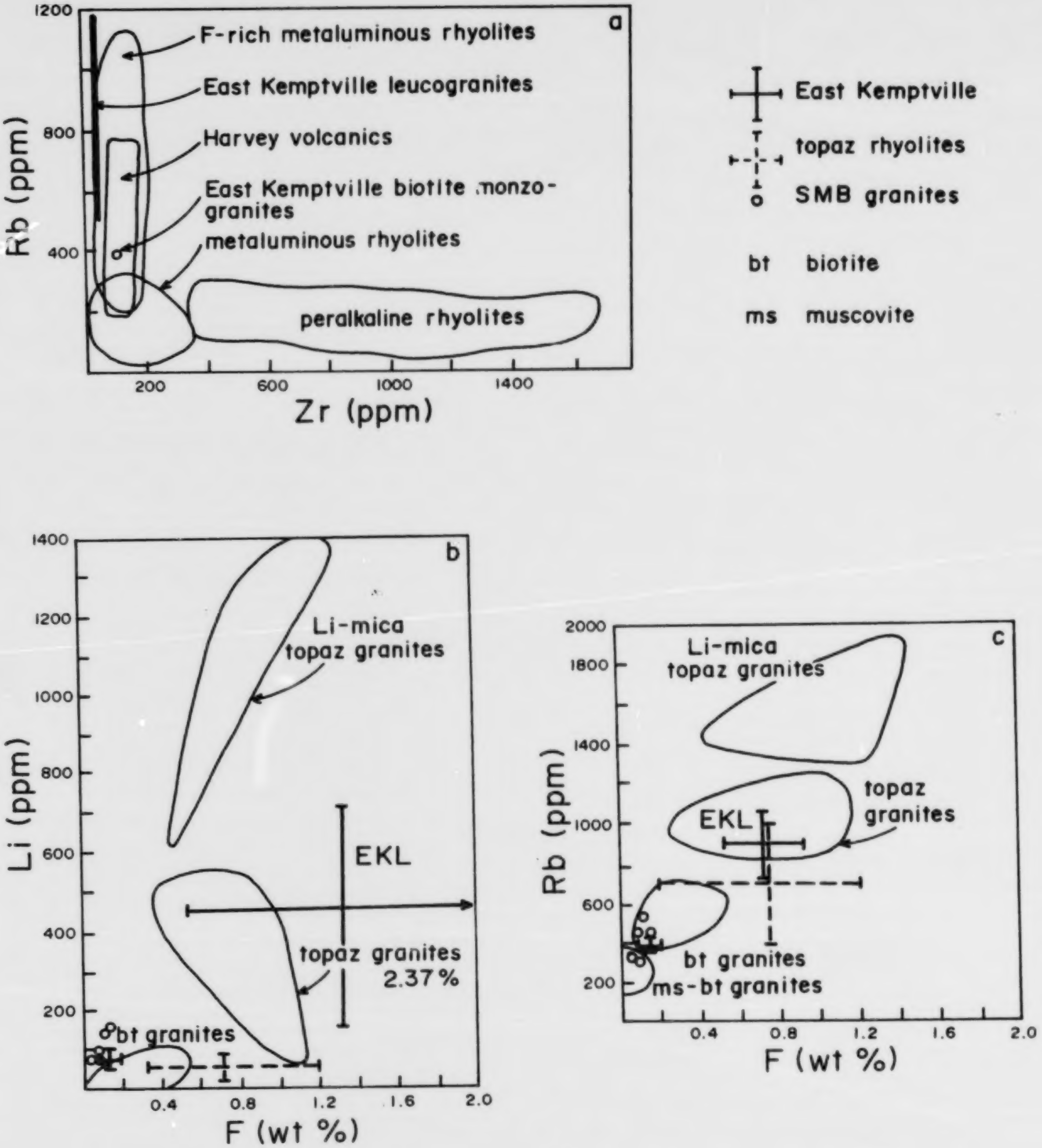

Figure 6. Geochemistry of the East Kemptville leucogranite (EKL) compared to data from other igneous suites. Rb versus Zr (6a) plot of Christiansen et al. (1983) comparing the data for the EKL and BMG to the fields outlined for a variety of rhyolite types. Also shown is the range for the F-rich Harvey volcanics of New Brunswick. Li versus F (6b) and Rb versus F plots (6c) for the EKL and BMG compared to the fields defined by Taylor et al. (1985) for Li-mica granites, topaz granites, biotite granites and biotite-muscovite granites. Data for the topaz rhyolites is from Christiansen et al. (1983) and for the SMB is unpublished data of Kontak.

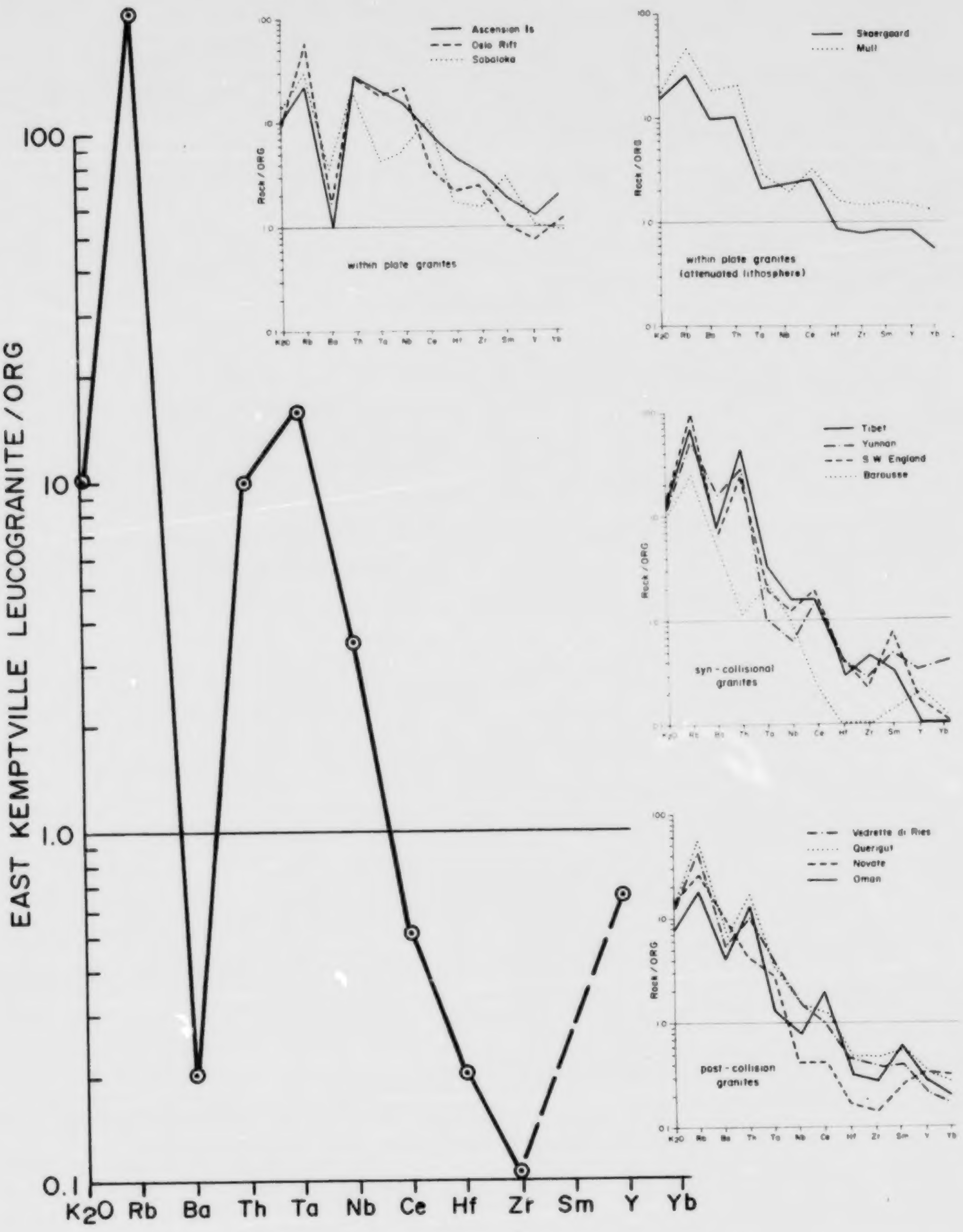

Figure 7. Average chemical data for the East Kemptville leucogranite (EKL) normalized to the ocean ridge granite (DRG) values of Pearce et al. (1984), and compared to various trends the same authors define for a range of granites from different tectonic environments. Note the strong depletion in Ba and Zr and the low abundances of the high field strength elements (Hf to Y).

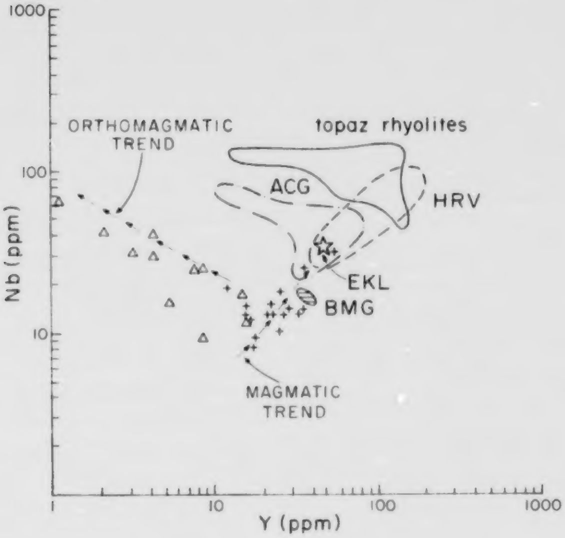

Figure 8. Plot of Y versus Nb for the EKL; (represented by the large star) and biotite monzogranite. Data for a variety of granites from the SMB (Kontak, unpublished data) define possible magmatic and orthomagmatic trends. Fields are also shown for some highly evolved rock suites: Ackley granite (ACG: Tuach et al., 1986), Harvey Volcanics (HRV: Payette and Martin, 1986), and topaz rhyolites (Christiansen et al., 1984).

permits enrichment of some elements, it also provides a mechanism for depleting the melt in the compatible elements such as Zr, Ba, Th and Sr by extending the range over which fractional crystallization processes are operative. The apparent low K_2O/Na_2O ratios of the EKL rocks are also accounted for by displacement of the minima in granite system towards more sodic-rich compositions because of the influence of the high F content on the chemistry of the melt.

The nonporphyritic and miarolitic-free nature of the EKL are features also consistent with the above interpretation. The F-rich suites are generally undersaturated in H_2O and are characterized by high aF/aH_2O in the melt. The absence of miarolitic cavities in the EKL rocks is compatible with the chemistry.

Finally, the distinct petrological features of the EKL require a mechanism for producing such a rock type. The presence of a shear zone in the East Kemptville area and the coincidence of this with an anticline in the adjacent country rock metasediments indicate that structural elements may form a role in the genesis of the EKL. It is suggested that the shear zone may represent a reactivated structure which was present prior to intrusion of the EKL and, probably, provided a weakness along which the melt was focused. If this structure was of crustal scale and penetrated to the ductile infrastructure, then perhaps it was in part responsible for generating the melts at depth by some combination of frictional melting in the presence of fluids. A similar mechanism has been previously suggested by Strong and Hanmer (1981) for the origin of leucogranites spatially related to the American Shear Zone in Brittany, France. If a high grade metamorphic basement was the source rock, then the process of melt generation may have been controlled by the break down of F-rich biotite and(or) amphibole (see Christiansen et al., 1983;

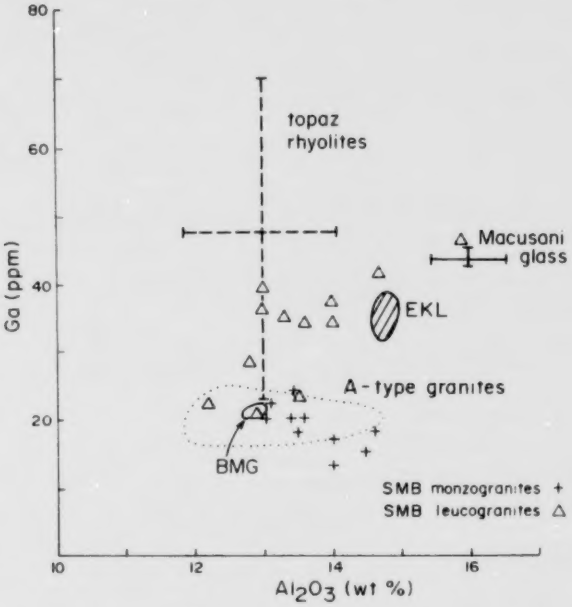

Figure 9. Plot of Ga versus Al_2O_3 for rocks of the EKL and BMG compared to the field defined for the Australian A-type granites from the Lachlan Fold Belt (after White and Chappell, 1983). Also shown for comparison are some F-rich suites represented by the Macusani glass, Peru (Pichavant et al., in press) and topaz rhyolites of the southwest United States (Christiansen et al, 1983), and also different granites from the SMB (Kontak, unpublished data).

1984; Clemens and Wall, 1981 for details). Melts generated in this way are generally enriched in volatile components and rare metals. It is suggested that the EKL represents such a melt.

Although the age of the EKL is not well constrained, a mid-Carboniferous time for the generation and emplacement of this intrusion is preferred. The reason being that (1) the EKL is at present considered petrologically distinct from evolved leucogranites which formed as late stage differentiates elsewhere in the SMB, and (2) magmatism of this age is known to have occurred in this part of southwest Nova Scotia as represented by the Wedgeport Pluton.

The above discussion, if correct, suggests that tin mineralization in southwest Nova Scotia is associated with a very distinct episode of magmatism of particular petrological character. If the East Kemptville area may be used as an example, exploration should be focused on the delineation of regional scale structures with associated granitic rocks that are similar to the EKL. The very unique chemistry and petrological features of these granites should make them easily recognizable and permit them to be distinguished from less fertile leucogranites.

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PERALUMINOUS GRANITES OF THE LISCOMB COMPLEX*

P. S. Giles and A. K. Chatterjee

The Liscomb Pluton, as defined by Faribault (1901, 1902), is an irregular bi-lobate granitic body covering an area of approximately 350 km^2 and is the second largest pluton in the eastern Meguma Zone. Geological mapping of the western half of the Liscomb Pluton has revealed that it is composite in nature (Fig. 1) consisting of (1) a plutonic complex covering an area of 75 km^2 (2) high-grade metamorphic rocks represented by felsic and mafic gneisses, and (3) two diatremes/breccia pipes characterized by a volatile-rich matrix ranging in composition from quartz-gabbro to quartz-diorite containing a large assortment of xenoliths. Thus, it is more appropriate to consider the Liscomb Pluton as the Liscomb Complex.

Geological observations and field relationships (i.e. intrusive contacts, abundance and types of xenoliths, structural trends, variations in rock types at outcrop scale and the lack of penetrative fabric) suggest that the entire complex is intrusive into the deformed and metamorphosed Cambro-Ordovician Meguma Group rocks. Thus, the complex is post-tectonic and the inferred diapiric mechanism of intrusion implies a rapid uplift and emplacement of the complex in a time frame which is bracketed by Acadian metamorphism (415-400 Ma) and granitoid intrusion (370 Ma) in the Meguma Zone (Reynolds and Muecke, 1978; Clarke and Halliday, 1980).

Regional airborne radiometric surveys clearly indicate a contrast in the respective radiometric response of the western and eastern lobes of the Liscomb Complex. This contrast was assessed by the examination of the granitoid rocks of the eastern lobe occurring in a section which approximates the variation from margin to the centre of the pluton. The authors have termed these rocks the Eastern Lobe monzogranite suite. The eastern lobe of the Liscomb Complex is presently the subject of a much broader investigation by K. Ford of the Geological Survey of Canada.

Granitic rocks of the western portion of the Liscomb Complex occur in 7 discrete plutons (Fig. 1):

1. Twin Lake granodiorite
2. East Loon Lake biotite monzogranite
3. Sanctuary biotite monzogranite
4. Nelson Lake muscovite biotite monzogranite
5. Porcupine Lake muscovite-biotite monzogranite
6. South Loon Lake muscovite-biotite monzogranite
7. Moose Lake muscovite-biotite monzogranite.

The latter four plutons are grouped together as "leucocratic monzogranite" because as a group they appear remarkably similar despite local variations in xenolith contents and varying host rock lithologies. Similarly, the East Loon Lake and Sanctuary monzogranites have been grouped together as they are characterized by a medium- to coarse-grained megacrystic texture and have similar mineralogy and chemistry.

The Twin Lake pluton appears to be the oldest granitoid unit and has a predominantly granodioritic composition. The granodiorite is grey (colour index ranges from 5.0 to 12.91), medium- to coarse-grained and consists of 45-55% plagioclase, 20-25% quartz, 5-15% quartz, 5-15% alkali feldspar and 5-10% biotite. In a few samples the rock is devoid of alkali feldspar. Accessory minerals are muscovite, apatite, zircon, garnet, chlorites and opaques. Variations within the pluton are largely controlled by textural changes, proportions of minerals and xenoliths. No conclusions were drawn with regard to possible zoning in the pluton.

The East Loon Lake and Sanctuary plutons have been intruded by leucocratic monzogranites, aplitic dykes and quartz-tourmaline-garnet dykes. These megacrystic plutons (predominantly biotite monzogranite) consist of 40-45% quartz, 15-25% plagioclase, 20-30% alkali feldspar, 5-10% phyllosilicates and >5% accessory mineral phases (apatite, zircon, tourmaline, garnet, pyrite and ilmenite).

The leucocratic monzogranites occur as discrete plutons and dykes cutting the Twin Lake, East Loon Lake and Sanctuary plutons and high-grade gneisses. They are equigranular and contain quartz, alkali feldspar and plagioclase as the essential mineral phases with subordinate amounts of phyllosilicates (muscovite > biotite), garnet, ilmenite, pyrite, and local minor chalcopyrite and sphalerite.

The Eastern Lobe monzogranite is fine grained along its western contact with Cambro-Ordovician Meguma Group metasediments, becoming medium- to coarse-grained with increasing distance from the contact. Thus, a crystallization cooling history from the margin inwards is indicated. The essential minerals are quartz, alkali feldspar and plagioclase, with a fluctuating proportion of biotite and muscovite. Assessory minerals include apatite, zircon, tourmaline, garnet, Fe-Ti oxides and rare sphalerite.

To investigate the distribution of major and trace elements in the granitic rocks, a total of 48 samples were analyzed by XRF, INAA and AA.

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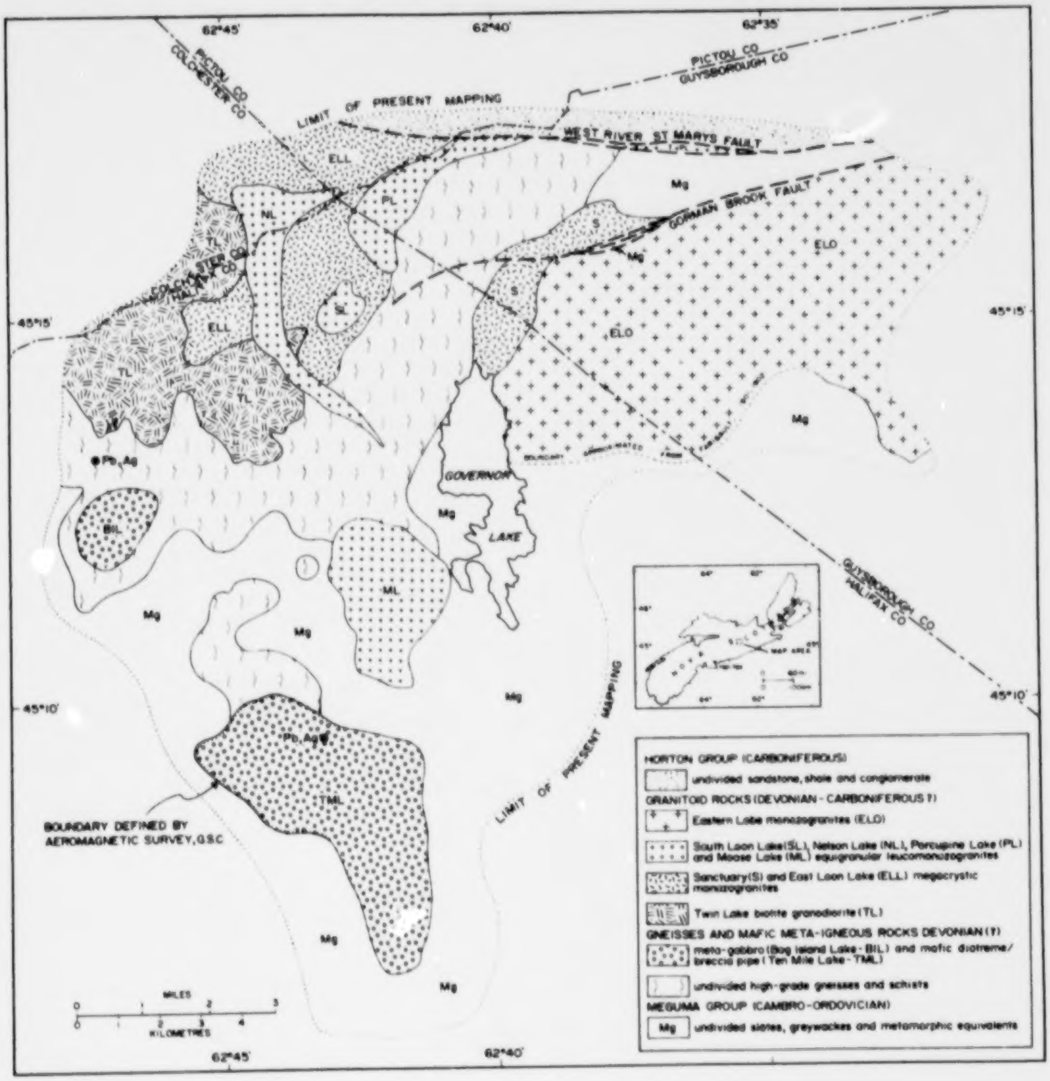
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PICTOU CO
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PICTOU CO
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LIMIT OF PRESENT MAPPING
WEST RIVER ST MARYS FAULT
GORMAN BROOK FAULT
COLCHESTER CO
HALIFAX CO
ELL
PL
NL
SL
TL
S
ELO
Mg
45°15'
Pb, Ag
BIL
ML
GOVERNOR LAKE
GUYSBOROUGH CO
HALIFAX CO
45°10'
TML
BOUNDARY DEFINED BY AEROMAGNETIC SURVEY, GSC
LIMIT OF PRESENT MAPPING
MILES
KILOMETRES
MAP AREA
HORTON GROUP (CARBONIFEROUS)
undivided sandstone, shale and conglomerate
GRANITOID ROCKS (DEVONIAN - CARBONIFEROUS ?)
Eastern Lobe monzogranites (ELO)
South Loon Lake (SL), Nelson Lake (NL), Porcupine Lake (PL) and Moose Lake (ML) equigranular leucomonzogranites
Sanctuary (S) and East Loon Lake (ELL) megacrystic monzogranites
Twin Lake biotite granodiorite (TL)
GNEISSES AND MAFIC META-IGNEOUS ROCKS DEVONIAN (?)
meta-gabbro (Bog Island Lake - BIL) and mafic diatreme/breccia pipe (Ten Mile Lake - TML)
undivided high-grade gneisses and schists
MEGUMA GROUP (CAMBRO-ORDOVICIAN)
Mg undivided slates, greywackes and metamorphic equivalents

Figure 1. Geological map of the Liscomb Complex, southern Nova Scotia

The Twin Lake granodiorite is represented by 12 samples, the megacrystic monzogranites of the East Loon Lake and Sanctuary plutons by 12 samples, the leucocratic monzogranites by 11 samples from 4 plutons and the Eastern Lobe monzogranite by 13 samples.

The A/CNK index of the granitic rocks from the Liscomb Complex ranges from 1.14 to 1.35 and hence these rocks as a whole are peraluminous. The variation diagrams shown in Figure 2 illustrate additional chemical characteristics of these granitic rocks:

- strong positive and negative correlations between major and trace elements such as Ba vs Sr (Fig. 2a) and SiO_2 vs MgO (Fig. 2b); these are relationships clearly established in differentiated suites of peraluminous granites of the Meguma Zone,
- strong depletion of Th with decreasing Th/U in the granitic suite as a whole (Fig. 2c),
- marked increase in U with decreasing Th in the Eastern Lobe monzogranites (Fig. 2d),
- decrease in Ti with increasing differentiation index (DI) in the granitic suite as a whole (Fig. 2e).

From the above, it may be argued that the negative correlation of SiO_2 with MgO, DI with Ti and the positive correlation of Ba with Sr are all indicative of magmatic differentiation

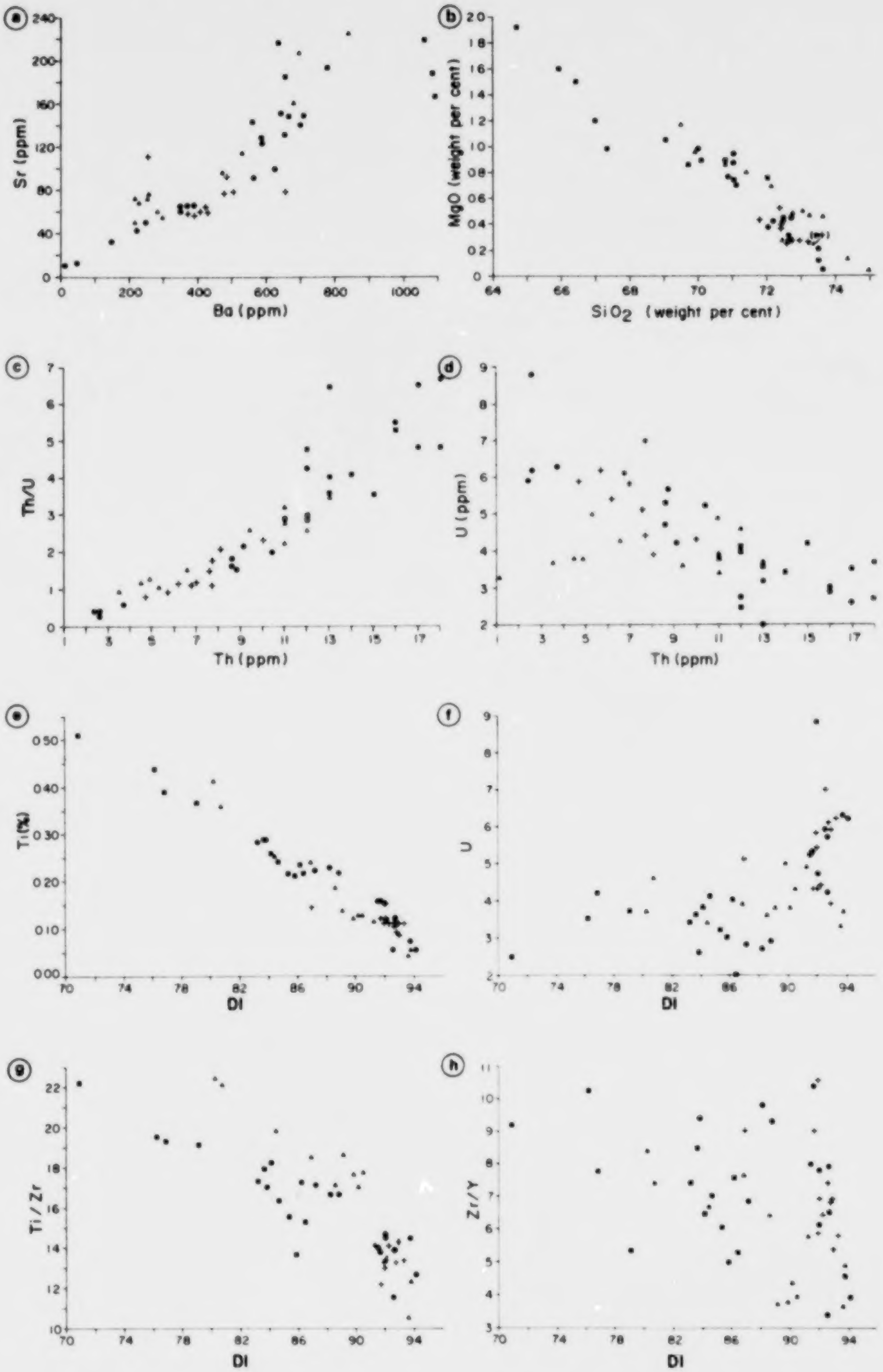

Figure 2. Major and trace element variation in peraluminous granites of the Liscomb Complex (solid square - Twin Lake granodiorite; solid triangle - megacrystic monzogranites, East Loon Lake and Sanctuary plutons; solid circle - Eastern Lobe monzogranites; cross - equigranular leucocratic monzogranites).

controlled to a large extent by fractional crystallization of biotite and plagioclase. However, other chemical features of our granitoid suite suggest that this simple model of differentiation from a single parental magma must be critically re-examined. Points to consider are as follows:

- a marked decrease in Th without significant uranium enrichment occurs in the Twin Lake pluton (granodiorite) and in the East Loon Lake/Sancturary plutons (megacrystic monzogranite) (Fig. 2d),
- the Th/U ratio values for Twin Lake granodiorite and Eastern Lobe monzogranites are similar for equivalent Th values (Fig. 2c),
- the insignificant U enrichment with increasing DI for the granodiorite and megacrystic monzogranite suites (Fig. 2f),
- the strong U enrichment with increasing DI for monzogranites of the Eastern Lobe (Fig. 2f), and
- plotted against DI (Fig. 2e), the range in Ti content is greatest for the megacrystic monzogranites (0.36%), compared with 0.30% in the potentially cogenetic granodiorite, a relationship incompatible with simple magmatic differentiation.

These features suggest alternatively that each pluton had its own crystallization history and that the initial trace element characteristics were largely controlled by source rock composition, degree of partial melting and other factors although the magmatic evolution was ultimately controlled by processes of fractional crystallization.

This suggestion can be further tested by considering the elemental ratios such as Ti/Zr and Zr/Y and the variation of these with the DI (Fig. 2g, h). It is clear that the Twin Lake granodiorite suite follows a distinct and separate evolutionary path from that of the East Loon Lake/Sanctuary megacrystic monzogranites, and the latter have a higher Ti/Zr ratio than the granodiorite suite at equivalent DI values. This characteristic feature alone demonstrates that the monzogranite bodies could not have derived solely from the differentiation of the granodiorite. Similarly, the Eastern Lobe monzogranites do not lie on either of these defined paths (Fig. 2g).

Because the leucocratic monzogranites have an extremely restricted Ti/Zr value, as all the highly differentiated monzogranites in the sample suite (Fig. 2g), the Zr/Y vs DI plot (Fig. 2b) is used to provide further insight. The Zr/Y values are similar for the granodiorites and megacrystic monzogranites as well as the most highly envolved leucomonzogranites. In addition, a linear trend defined by the leucomonzogranites indicates clearly that the high silica rocks of the western lobe were derived solely through differentiation of either the granodiorite or the megacrystic monzogranite suites.

In summary, the field relationships, the recognition of discrete mappable plutonic bodies, and the major and trace element chemistry lead to the following conclusions:

- The peraluminous granite suite, high-grade felsic and mafic gneisses, and mafic meta-igneous rocks are part of the Liscomb Complex. The entire complex is disharmonic with its surroundings and therefore, considered post-tectonic with a diapiric emplacement mechanism.
- The plutons are petrologically variable, each with a distinct evolutionary history. It is unlikely that all of the granitic rocks are products of differentiation from a single parental magma.
- The four suites of granitic rocks show discrete differentiation trends, perhaps controlled by crystal fractionation of phases such as plagioclase, biotite, monazite and probably also Fe-Ti oxides.
- Silica variation diagrams involving major and trace elements portray systematic changes, but are not a definitive indicator of magmatic differentiation from a single parent magma.
- The Th/U, Ti/Zr and Zr/Y ratios in combination with DI are important parameters with which the crystallization history of the plutons can be assessed. The ratios provide constraints on the interpretation of possible source rocks for the plutons. The nature of these source rocks may be fundamental to metallogenic specialization in the peraluminous granitoids of southern Nova Scotia as suggested by Chatterjee et al. (1983).

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GEOLOGY OF THE DEAN AND CHAPTER MANGANESE MINE AND SURROUNDING AREA, LUNENBURG COUNTY, NOVA SCOTIA*

G. A. O'Reilly

INTRODUCTION

The Nova Scotia Department of Mines and Energy (NSDME) carried out a diamond-drill program at the Dean and Chapter Manganese Mine in the South Mountain Batholith, northeast of New Ross, Lunenburg County from October 1985 to February 1986 (Fig. 1). The program consisted of three drillholes designed to (1) investigate at depths of 250, 550 and 1200 ft, for downward extensions of the known deposits and (2) provide complete sections of the mineralized zones for petrographic and geochemical studies (Fig. 2; O'Reilly, 1985). The data collected will aid in obtaining an understanding of the genetic origin of these deposits, which has been a point of disagreement among past workers. Kramm (1912) and Douglas and Campbell (1942) favored a supergene origin for the deposits while Hewett (1972) and Bishop and Wright (1974) presented evidence suggesting the deposits are of hypogene origin. A downhole geophysical survey (total gamma ray response) was conducted on two selected holes, namely D&C 85-1 and D&C 85-3 (Fig. 3).

Detailed core logging (scale 1 cm:5 ft) has documented the spatial distribution of various rock types and alteration facies resulting from fluid-rock interactions associated with the mineralization. Geological mapping in the vicinity of the manganese mines (Fig. 1) and the new drill results demonstrate the strong association of mineralization and hydrothermal alteration at the Dean and Chapter Mine.

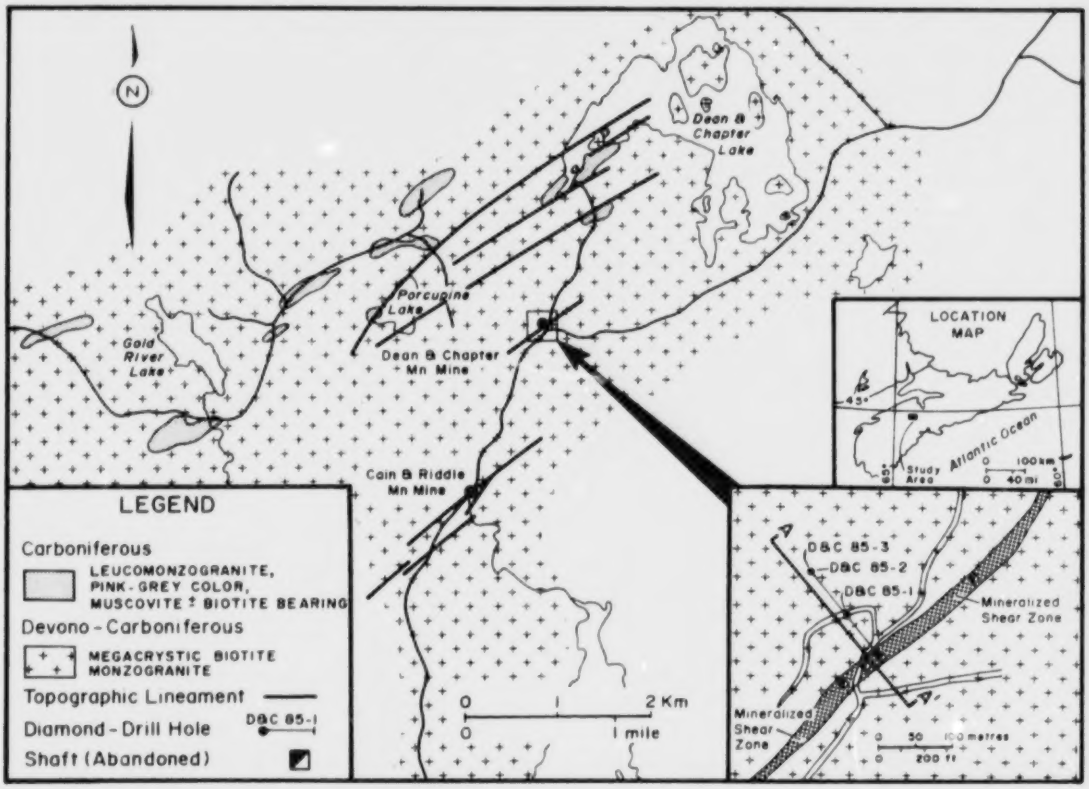
N
Dean & Chapter Lake
Porcupine Lake
Gold River Lake
Dean & Chapter Mn Mine
Cain & Riddle Mn Mine
LOCATION MAP
45°
Atlantic Ocean
Study Area
0 100km
0 40mi
65°
60°
LEGEND
Carboniferous
LEUCOMONZOGRANITE, PINK-GREY COLOR, MUSCOVITE ± BIOTITE BEARING
Devono-Carboniferous
MEGACRYSTIC BIOTITE MONZOGRANITE
Topographic Lineament
Diamond-Drill Hole D&C 85-1
Shaft (Abandoned)
0 1 2 Km
0 1 mile
D&C 85-3
D&C 85-2
D&C 85-1
Mineralized Shear Zone
Mineralized Shear Zone
0 50 100 metres
0 200 ft

Figure 1. Geology of the South Mountain Batholith in the vicinity of the New Ross Manganese Mines. Location of recent diamond-drill holes at the Dean and Chapter Mine are given in the inset. Cross-section along A-A' is shown in Figure 2.

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

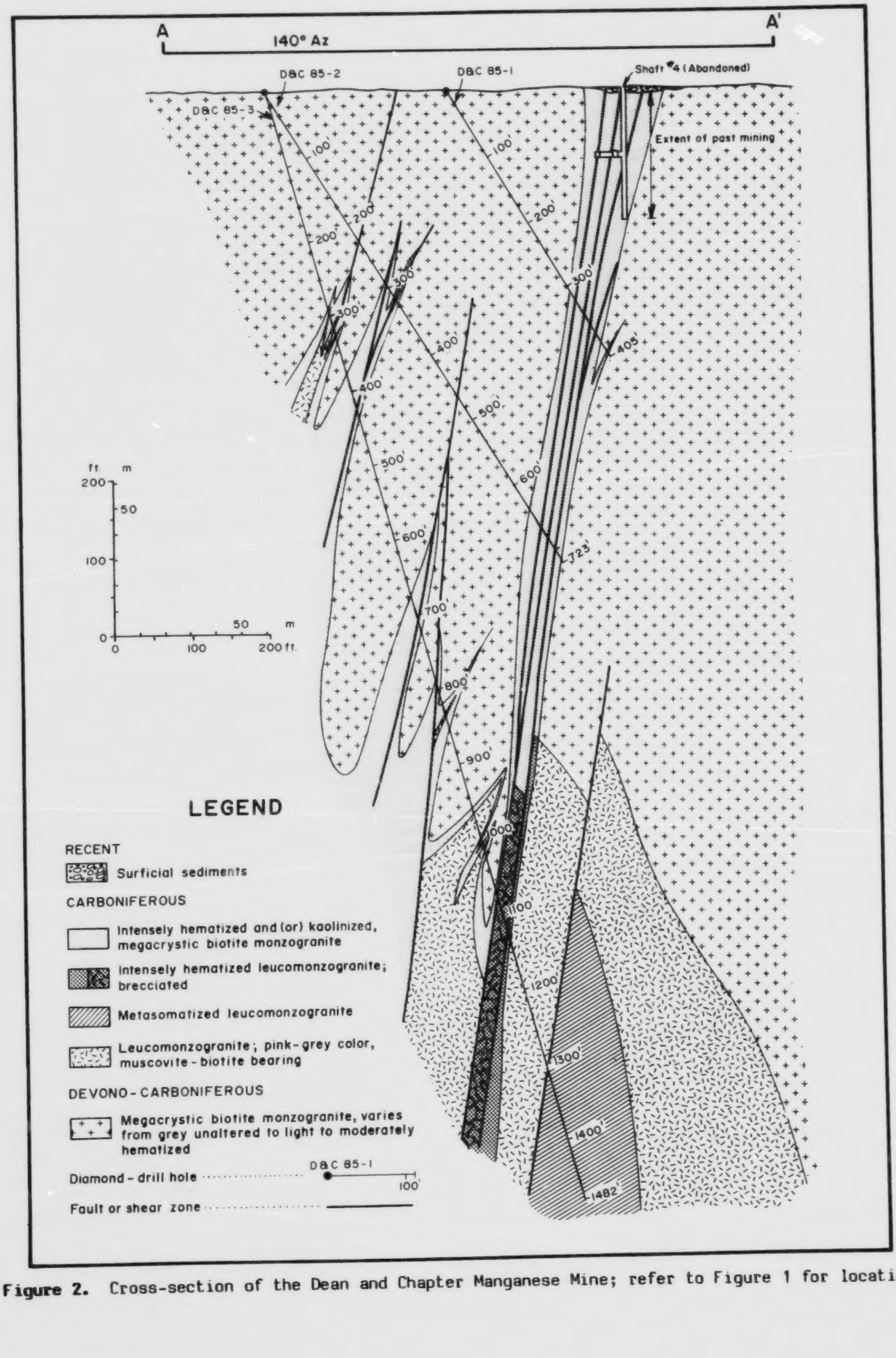

A
A'
140° Az
D&C 85-2
D&C 85-3
D&C 85-1
Shaft #4 (Abandoned)
Extent of past mining
100'
200'
300'
400'
405'
500'
600'
700'
723'
800'
900'
1000'
1100'
1200'
1300'
1400'
1482'
ft
m
200
50
100
0
0
100
200 ft.
50
m
LEGEND
RECENT
Surficial sediments
CARBONIFEROUS
Intensely hematized and (or) kaolinized, megacrystic biotite monzogranite
Intensely hematized leucomonzogranite; brecciated
Metasomatized leucomonzogranite
Leucomonzogranite; pink-grey color, muscovite-biotite bearing
DEVONO-CARBONIFEROUS
Megacrystic biotite monzogranite, varies from grey unaltered to light to moderately hematized
Diamond-drill hole
D&C 85-1
100'
Fault or shear zone

Figure 2. Cross-section of the Dean and Chapter Manganese Mine; refer to Figure 1 for location.

This investigation is expected to stimulate interest in the potential for similar or related mineral deposits in this and other areas of the South Mountain Batholith.

DRILLING RESULTS

The Dean and Chapter Manganese Mine consists of four shafts along a single northeast trending mineralized zone (Bishop and Wright, 1974). Mining operations commenced in 1910 and continued until 1921. The mine was reopened in 1929 and was operated on a small scale until 1936. A small quantity of ore was removed for the war effort but since the thirties work at the mine has been limited and of a developmental nature.

The deposits occur as lense-like veins of manganese oxides within a zone of highly altered biotite monzogranite which dips steeply toward the northwest. Past mine workings were restricted to within 200 ft of surface. This reflects the bias of previous workers that the deposits were formed by supergene processes and were uneconomic at depth. This conclusion governed mine operations even though there were drill intersections of significant mineralization at depths up to 340 ft.

Each of the three holes drilled for this project collared in cordierite-bearing, megacrystic biotite monzogranite. This host rock is typical of rocks underlying much of the area of the South Mountain Batholith north of New Ross (MacDonald et al., 1986).

The megacrystic monzogranite was subjected to varying degrees of hematization. The effects of this iron metasomatism are recorded sequentially as absent, light, moderate or intense reddening of color depending on the degree of alteration. Unaltered monzogranite has a fresh grey hypidiomorphic granular texture that with the onset of hematization assumes a definite reddish tinge due to selective alteration of plagioclase. Potassic feldspar, quartz and biotite are visually unaffected and maintain their original characteristics. No pervasive structural control of the light to moderate hematized facies was observed. This suggests that the hematization processes are pervasive and affected large volumes of the monzogranite away from the mineralized zones. The more intensely hematized rocks are invariably associated with joints, shear zones, faults and veins (Fig. 3). At this stage the plagioclase is brick red in color while the cream-colored potassic feldspar is often hematized along grain boundaries and internal fractures.

DDH D&C 85-1

This drillhole was drilled on an azimuth of 140° at an inclination of -60°. It intersected and cored the northeast trending mineralized zone at a downhole depth of 304 ft (260 ft vertical; Fig. 2). This is a short distance below the deepest past workings of 200-230 ft. The zone persists to a downhole depth of approximately 380 ft and consists of such various intensely altered facies as kaolinized monzogranite, hematized and kaolinized monzogranite, and intensely hematized monzogranite. According to past reports the kaolinized monzogranite extends to this depth but due to its very soft nature it does not outcrop (Douglas and Campbell, 1942). The alteration facies retain the texture and appearance of the original monzogranite but are so intensely altered that within a few hours of exposure to air become very crumbly. The plagioclase is completely replaced by clay minerals (most commonly kaolin) while potassic feldspar is greenish in color due to sericitization. The highly sericitized potassic feldspar remains competent.

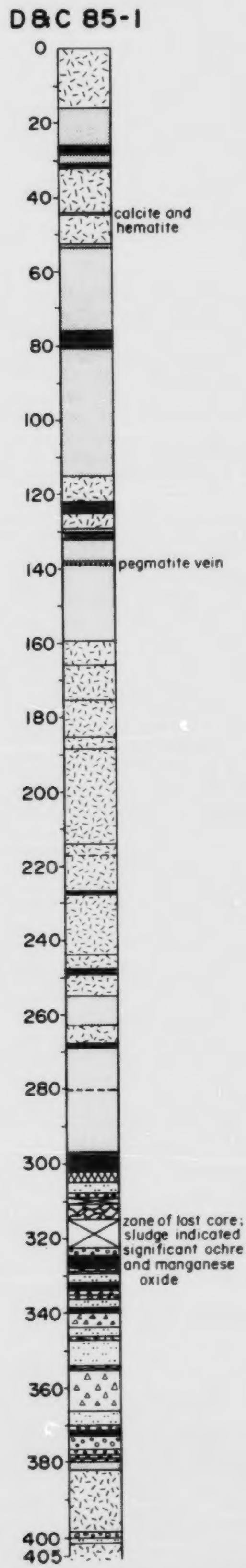
Manganese mineralization is associated with the most intensely hematized facies and occurs as massive lenses within breccia systems of hematite and ochre. There was no core obtained from the 309-311 ft and 315-322.5 ft sections. This is unfortunate as drill cuttings and chips suggest that the latter section consists of a zone of highly hematized monzogranite and ochre centred by a significant length of manganese oxide. Historically, the manganese deposits of New Ross were reported to host the highest concentration of mineralization within 30 ft of the competent hangingwall (Bishop and Wright, 1974). Several smaller veinlets of manganese oxide occur downhole from the lost sections (Fig. 3). Manganese oxide veinlets occur with massive apatite within a 4 ft thick zone of silicification and quartz breccia.

The zone of intensely hematized and kaolinized monzogranite and a portion of the more competent hangingwall and footwall were surveyed for total gamma ray response by the Nova Scotia Research Foundation Corporation (Fig. 3). The fresh moderately hematized facies of the hangingwall and footwall monzogranite gives a constant response averaging 28 counts per second (cps). Within the highly altered zone, the response varies considerably from 21 to 90 cps.

DDH D&C 85-2

This drillhole was drilled on an azimuth of 140° and inclination of -60°. It intersected and cored an altered zone(s) at a downhole depth of 641 ft (550 ft, vertical; Fig. 2). The hangingwall to the zone consists of similar variably hematized facies of the megacrystic monzogranite encountered in the first hole. Hematite-ochre breccia and vein stockworks occur, but the pods and veinlets of Mn oxides observed in the previous hole are absent.

At a downhole depth of 290-320 ft a zone of intense hematization and brecciation surrounds a silicified and brecciated dyke of pink-grey leucogranite. The leucogranite has a fine grained, sugary, aplitic texture. The silicification occurs along the borders of the dyke, and grades inward and along the interstices between the brecciated fragments. In addition the monzogranite, where adjacent to the leucogranite, often has a thin silicified zone which grades outward into an orange colored alteration facies of the monzogranite. This orange colored monzogranite accompanies similar silicified zones



LEGEND

CARBONIFEROUS OR YOUNGER

■ **Manganese oxide bearing zone:** massive lenses and pods of black manganese oxides; generally associated with hematite-ochre breccias and intensely hematized zones

▦ **Hematite-ochre breccia:** brick red and fine grained matrix of quartz, hematite and ochre; usually occur within shear and fault zones at the cores of intensely hematized zones

□ **Silicified zones:** silicified zones retain some remnant texture of the original rock; commonly occur as border facies of highly-hematized and brecciated leucomonzogranite dykes; one occurrence (D&C 85-1) grades into a quartz breccia dyke containing manganese oxides

△ **Intensely hematized ± kaolinized monzogranite:** extremely hematized but still retains some of the original hypidiomorphic granular texture; generally borders intensely hematized shear and fracture zones, breccias and manganese mineralization

⁘ **Kaolinized and hematized monzogranite:** completely kaolinized plagioclase and sercitized orthoclase is accompanied by some degree of hematization; hematization has imparted a reddish color to the plagioclase

░ **Kaolinized monzogranite:** completely kaolinized plagioclase and intensely sericitized orthoclase; this phase has retained its megacrystic, hypidiomorphic granular texture but is now extremely soft due to the complete kaolinization

▩ **Orange monzogranite:** strong orange and(or) brown color imparted to plagioclase and orthoclase; this alteration facies is transitional from the intensely hematized facies and silicified zones and hematite-ochre breccias

■ **Highly hematized monzogranite:** intense red-brown color is predominantly restricted to plagioclase although orthoclase has red staining along fractures and grain boundaries

□ **Moderately hematized monzogranite:** brown-purple color due to hematization of plagioclase

▤ **Intensely hematized leucomonzogranite:** red-brown; closely associated with zones of brecciation

▧ **Desilicified leucomonzogranite:** vuggy and pitted texture due to removal of quartz by hydrothermal alteration; desilicification is accompanied by a significant degree of hematization

▤ **K-feldspathized leucomonzogranite:** fine grained phase consisting predominantly of orthoclase and quartz with minor amounts of muscovite

DEVONO-CARBONIFEROUS

▨ **Leucomonzogranite:** light grey-pink; fine- to medium-grained; minor biotite

░ **Megacrystic biotite monzogranite:** fresh, lightly hematized phase; grey to light brown; minor cordierite

Figure 3. Sections and downhole total gamme ray surveys from recent NSDME drilling at the Dean and Chapter Managanese Mine; see Figure 1 for drillhole locations.

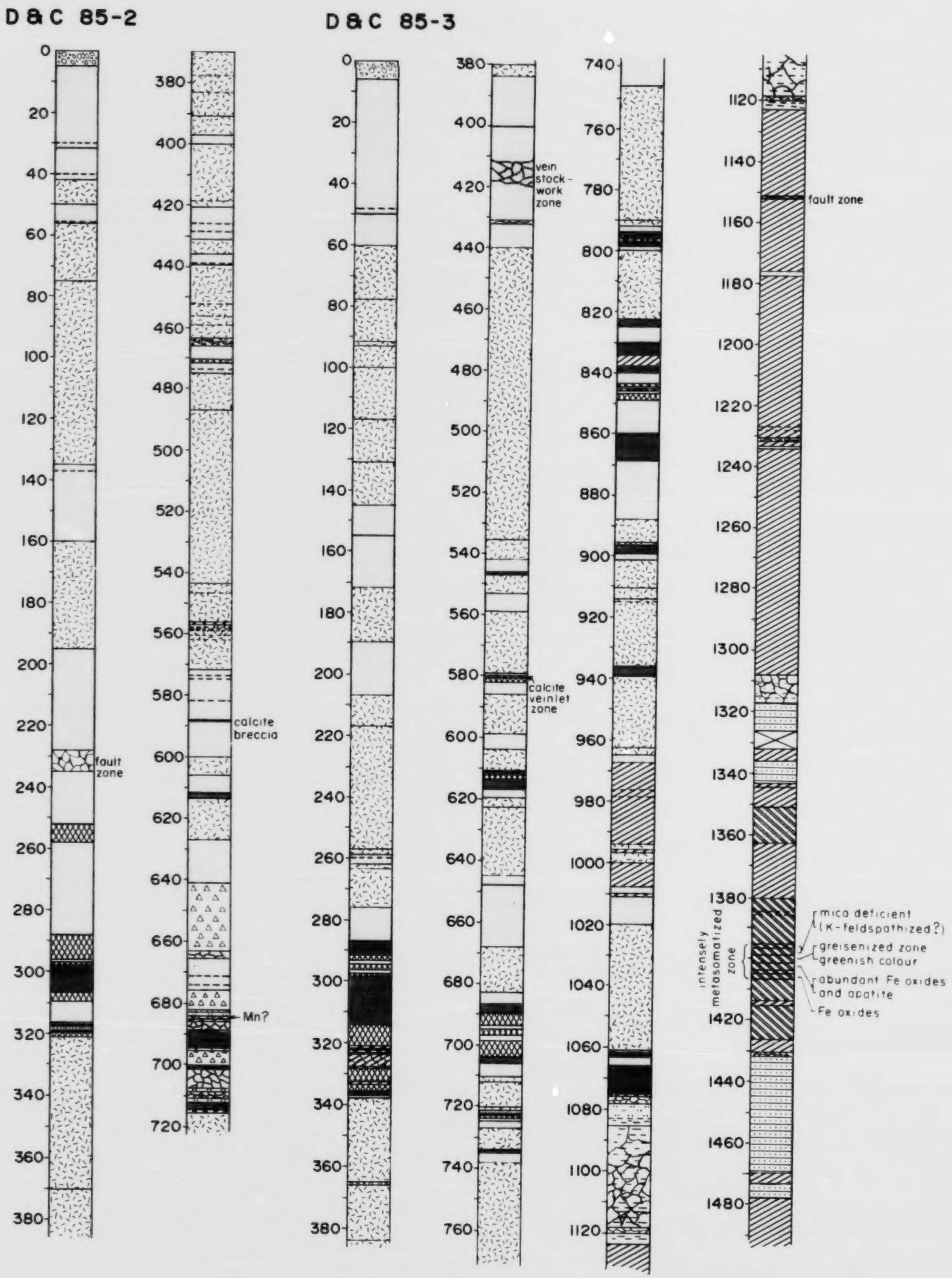

D&C 85-2
fault zone
calcite breccia
Mn?
D&C 85-3
vein stock-work zone
calcite veinlet zone
fault zone
mica deficient (K-feldspathized?)
greisenized zone
greenish colour
abundant Fe oxides and apatite
Fe oxides
intensely metasomatized zone

Figure 3. Continued

observed throughout the drillholes. The orange color was imparted to plagioclase and potassic feldspar.

The highly hematized and kaolinized zone corresponding to the mineralized zone in upper levels was intersected from 641-715 ft. Alteration facies similar to those observed in the zone in DDH 85-1 occur at this depth, except that kaolinization is usually accompanied by some degree of hematization. The transition from the moderately highly hematized but competent monzogranite into the intensely hematized and kaolinized crumbly facies is gradational when compared with D&C 85-1.

DDH D&C 85-3

This hole was collared at the same location as D&C 85-2 and was drilled along 140° Az at an inclination of -75° (Fig. 2). It was positioned to test for the continuation of the zone(s) at a vertical depth of 1200 ft. Hematized monzogranite similar to that previously described occurs to a downhole depth of 1085 ft. Zones of intense hematization and silicification and the occurrence of sections of orange monzogranite are associated with minor intrusions of pink-grey leucogranite at downhole depths of 325, 695, 835 and 967-1010 ft (Fig. 3).

The hole cored a pink-grey leucogranite-leucomonzogranite complex from 1085 ft to total depth at 1482 ft. The contact between the megacrystic monzogranite and the leucomonzogranite is marked by a 30 ft fault zone containing highly hematized and brecciated leucomonzogranite. This zone coincides with the fault zones recognized in the first two holes. Thus, the zone persists to 1100 ft with no evidence of weakening or pinching out at depth. The bottom 170 ft of the leucomonzogranite is marked by variously hematized and metasomatized facies alteration (Fig. 3).

Potassium metasomatism has resulted in a K-feldspathized leucomonzogranite. This rock is orange-pink, dominated modally by potassic feldspar and contains little or no mica. This facies grades into typical pink leucomonzogranite over intervals from 1-5 ft.

The second dominant alteration has produced a considerable thickness of desilicified leucomonzogranite. Sections of this rock have a typical brownish, pitted or vuggy appearance. The pitted or vuggy texture is due to the leaching of free quartz from the rock. The desilicified sections grade into pink leucomonzogranite but the relationships between the K-feldspathized, desilicified and silicified rocks are not established.

The total gamma ray response of the entire section of D&C 85-3 was surveyed by the Nova Scotia Research Foundation Corporation (Fig. 3). The fresh-moderately hematized facies of the monzogranite gives a relatively constant response of 40 cps. However, the relatively flat response of the pink-grey leucomonzogranite compared to the megacrystic monzogranite is noteworthy. Characteristically, the more leucocratic phases within the South Mountain Batholith have an elevated gamma ray response (Ford and O'Reilly, 1985). The K-feldspathized and desilicified facies exhibit an elevated and variable radiometric response. This is expected considering these rocks have undergone significant fluid-rock interaction. Such processes are commonly associated with an elevation of granophile element content (Ford and O'Reilly, 1985).

RESULTS OF GEOLOGICAL MAPPING

The area surrounding the New Ross Manganese Mines is underlain by similar megacrystic biotite monzogranite observed in the core from the drilling project (Fig. 1; MacDonald et al., 1986). The monzogranite is generally grey although areas have undergone a slight degree of hematization resulting in a reddening of plagioclase. Outcrops of moderately-highly hematized monzogranite are uncommon but where observed invariably occur along northeast-southwest trending topographic lineaments. The scarcity of outcrop of these more highly hematized rocks may be due to their soft nature and hence, preferential erosion.

A number of small elongate plutons of pink-grey leucomonzogranite occur north and west of the Dean and Chapter Mine (Fig. 1). These plutons are in both intrusive and faulted contact with the monzogranite. They have similar texture, composition and exhibit some similar alteration features to the leucomonzogranite intruded at depth below the Dean and Chapter Mine. Areas of hematization within the leucomonzogranites are spatially associated with faulted contacts and some intrusive contact zones with the enclosing monzogranite.

Air photo interpretation of this area of the batholith shows a pronounced system of northeast-southwest trending topographic lineaments. These lineaments have the same orientation as the mineralized zones at the Dean and Chapter and the Cain and Riddle Mines (Fig. 1). Coincidently, the orientation of the small leucomonzogranite intrusions in the map area parallel this trend. This infers that these small leucomonzogranitic intrusions exploited a northeast-southwest trending fracture system. Field mapping and core logging suggest that there was post-emplacement shearing of the monzogranite and leucogranites along this fracture system. In addition, outcrops of the monzogranite and leucomonzogranite in close proximity to the lineaments (within 100 yds) have undergone a significant degree of hematization.

SUMMARY AND CONCLUSIONS

The petrographic and geochemical studies on the material collected during the field season have been recently initiated but certain inferences can be made from the field observations:

- The northeast-southwest trending zones hosting manganese mineralization and associated alterations are deep-seated fault systems. The contention that the vein systems hosting the New Ross manganese deposits are a near surface supergene phenomena is now suspect.

- Drilling by the Nova Scotia Department of Mines and Energy indicates that significant manganese mineralization extends to a depth of at least 260 ft at the Dean and Chapter Mine. Previously, manganese mineralization at this mine was not reported below approximately 200 ft.
- Alteration is zoned with depth from a hematization and kaolinization dominated system to a hematization dominated system.
- A variably hematized and metasomatized leucomonzogranite intrusion has intruded along a fault zone at depth below the Dean and Chapter Mine. This same fault zone hosts the manganese-oxide-bearing veins which were mined within 200 ft of surface.
- There is a spatial association of the leucomonzogranite and related dykes with zones of silicification and intense hematization of both the leucomonzogranite and the enclosing megacrystic monzogranite. This infers a genetic relationship exists between the intrusion of the leucomonzogranite and the alteration processes accompanying the manganese mineralization.
- Core logging and geological mapping suggest that similar structural features to those mineralized at the mines occur throughout this area of the batholith. These features allowed the passage of hematizing hydrothermal fluids and therefore have the potential to host similar deposits.

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THE GEOLOGY OF THE SOUTH MOUNTAIN BATHOLITH: NTS MAP SHEETS 21A/09, 21A/10, 21A/15 AND 21/A16(WEST)

M. A. MacDonald, M. C. Corey, L. J. Ham and R. J. Horne

INTRODUCTION

During the 1986 field season geological mapping was conducted on NTS map sheets 21A/09, 21A/10, 21A/15 and 21A/16 (west). This mapping is part of an ongoing mapping project which was initiated in 1985 and is designed to generate 1:50 000 scale geological maps of the South Mountain Batholith (SMB). To date, more than half of the mapping is complete (Fig. 1) with the remainder to be covered by the end of the 1987 field season.

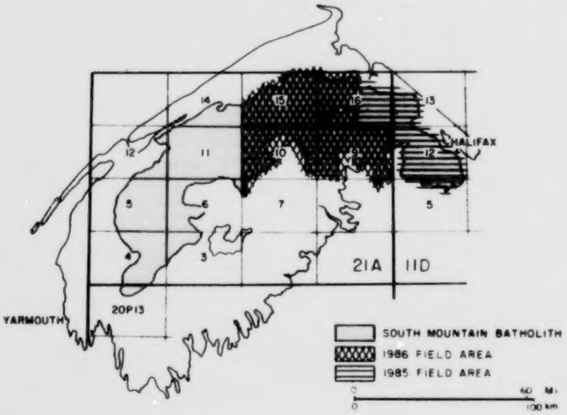

Figure 1. Location map showing 1985 and 1986 field areas

Recent mapping by the SMB project has resulted in a much improved understanding of the batholith by establishing criteria for subdividing the SMB into distinct mappable units (Table 1) and delineating the distribution of individual units (Fig. 2). This report is a summary of the 1986 mapping with highlights of some of the more interesting aspects of the geology of the SMB.

The batholith has been the subject of numerous papers, theses and Nova Scotia Department of Mines and Energy publications on topics ranging from geochemistry and alteration/mineral deposit studies to petrology and petrogenesis. In addition, the SMB has been the target of many mineral exploration programs. Table 2 outlines some of the more important contributions and is indicative of the diversity of work done since the early 1970s.

GENERAL GEOLOGY

UNIT DESCRIPTIONS

Subdivision of the granitoid rocks into distinct mappable phases is based on texture (e.g. equigranular, porphyritic, hypidiomorphic granular, seriate), grain size (fine= <0.1 cm, medium= 0.1-0.5 cm, coarse= >0.5 cm), and visual estimates of the modal percentages of biotite, muscovite, cordierite and alkali feldspar megacrysts (Table 1). Modal percentages of quartz, alkali feldspar and plagioclase, established from point counting of stained slabs, were used to determine lithologic type according to the Streckeisen (1976) classification scheme.

Repetition of similar units throughout the eastern half of the SMB permits grouping of all units into nine major descriptive categories as follows: (1) mafic porphyry,(2) granodiorite, (3) transitional granite, (4) biotite monzogranite, (5) medium- to coarse-grained megacrystic 2-mica monzogranite, (6) fine- to medium-grained equigranular 2-mica monzogranite, (7) porphyry (monzogranite), (8) intrusive suites and (9) leucogranite suites.

MAFIC PORPHYRY

The term mafic porphyry has been applied to a distinct group of rocks which (1) are generally fine- to medium-grained, (2) are porphyritic with phenocrysts of quartz, alkali feldspar and plagioclase and (3) contain an anomalously high percentage of biotite (15-20%). Mafic porphyries commonly contain numerous small (average 10 cm), biotite-rich xenoliths (often >90% biotite). Volumetrically mafic porphyries constitute a small portion of the SMB, generally covering only a few km^2 or less. Although the mafic nature of these rocks would suggest they were early in the magmatic sequence, some field evidence indicates they can postdate the intrusion of the 2-mica monzogranites.

GRANODIORITE

Areas designated as granodiorite are underlain by rocks which consistently plot in the granodiorite field of the Streckeisen classification diagram.

Granodiorite is commonly medium- to coarse-grained, hypidiomorphic granular and somewhat megacrystic (predominantly alkali feldspar), although medium grained, equigranular, marginal phases also exist (at country rock contacts). Biotite content ranges 12-15 % while muscovite is

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

Table 1. Legend of granite rocks of 21A/09, 21A/10, 21A/15 and 21A/16

UNIT	UNIT NAME	COLOUR	GRAIN SIZE	TEXTURE	% BI*	% MU*	% CD*	% MEGACRYSTS	XENOLITHS	NOTES
LEUCOGRANITE AND LEUCOGRANITE INTRUSIVE SUITES (BIOTITE <2%)										
DClmgBB	Burnt Blanket Hill Complex	buff, white	fine to medium	variable	1-5	1-2	0-1	0	none	contacts with DCmgMR both sharp and gradational
DClgKR	Keddy Reeves Leucogranite	white-buff	medium	equigranular	0-2	1-4	0	0	none	lack of biotite
DClgLL	Lake Lewis Leucogranite	white, cream, buff	fine to medium	equigranular	1-2	2-3	0	0	none	low biotite content
DClgLO	Long Lake Leucogranite	buff	fine to medium	equigranular	1	4	0	0	none	high muscovite content
DClgML	Murphy Lake Leucogranite	white, grey, orange, pink,	fine to medium to coarse	equi-granular, aplitic, porphyritic, pegmatitic,	0-5	2-4	0	0	none	complex (i.e. heterogeneous textures with abundant pegmatitic material as pods and dykes)
BIOTITE-MUSCOVITE MONZOGRANITE (EQUIGRANULAR)										
DCmgBL	Bates Lake Monzogranite	light grey, buff, dark red	fine	equigranular	4-7	trace	trace	0	none	minor medium grained variation
DClmgCA	Canoe Lake Leucomonzo-granite	white, buff	medium	equigranular	2-5	1-3	0	<1	none	low biotite content; biotite looks almost translucent
DClmgGR	Gold River Leucomonzo-granite	grey, buff, orangish-red	fine	equigranular	<2-5	1-2	0	0	none	low biotite content; moderately hematised; extremely hard (siliceous)
DCmgML	Millet Lake Monzogranite	medium grey	fine to medium	equigranular	8-10	2-4	0	0	rare	development of fluorite along fracture faces; greisening and quartz stockwork
DCmgOL	Otter Lake Monzogranite	white-cream	medium	equigranular	<1-5	<1-2	0	0	none	non-megacrystic; low biotite content; miarolitic cavities
PORPHYRY (<5% BIOTITE)										
DCmgpKR	Keddy Reeves Porphyry	buff-orange	fine to medium	porphyritic	4-6	1-3	0-<1	0	none	fine grained porphyritic texture; similar to porphyry elsewhere in the SMB
DCmgp	Porphyry	whitish grey, orangish-brown	fine to medium	porphyritic	<2-7	2-<5	<1-1	0-5	none	porphyritic texture
INTRUSIVE SUITES										
DCmgBI	Big Indian Lake Polyphase Intrusion									mineralogically similar but texturally variable phases; intimately associated and form sharp but irregular contacts; presence of garnets; coarse grained, slightly megacrystic biotite granodiorite roof pendants of variable size within polyphase
Comprised of:	porphyry	buff, light grey	fine to medium with coarse grained pheno-crysts	porphyritic	3-10	trace-1	0	0		
	microgranite	buff, white	very fine grained	saccharoidal	≤5	trace-1	0	0		
	fine- to medium-grained monzogranite	buff, orange, brown	fine to medium	equigranular seriate	3-6	1-4	1	0		
	coarse grained monzogranite	medium grey, buff	coarse	seriate hypidio-morphic granular	4-8	trace-3	trace-2	<2		
DCmgTCa	Tantallon Complex	buff, orange	fine to medium	variable	0-5	1-4	0-2	<5	none	greisen veins

*BI = biotite
MU = muscovite
CD = cordierite

present in only trace amounts. Xenoliths of Meguma Group rocks and unrecognizable rock type are common to abundant in this unit, constituting up to >1 % of the rock volume.

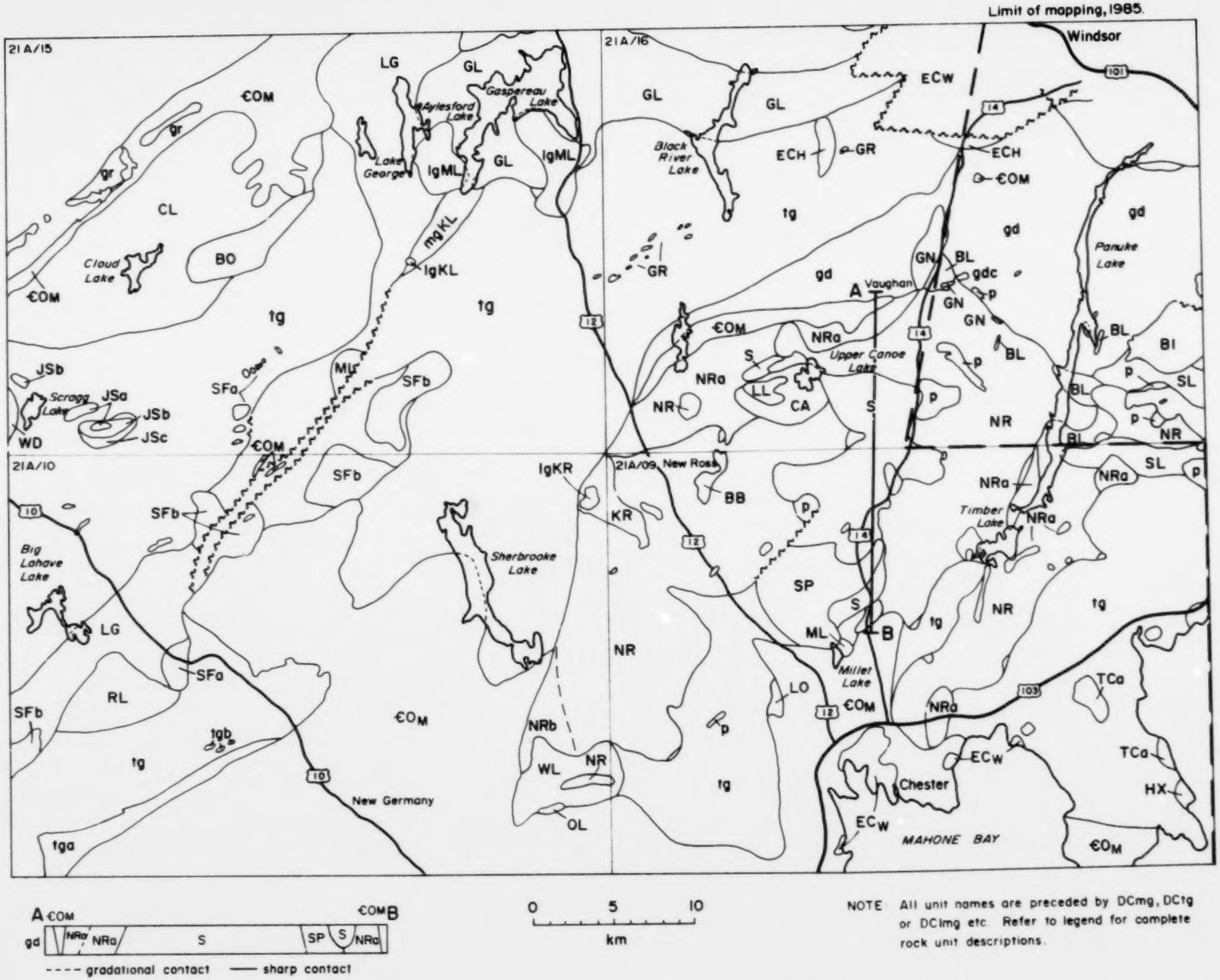
TRANSITIONAL GRANITE

Transitional granite refers to those rocks in which the modal compositions range from

Table 1. Continued

UNIT	UNIT NAME	COLOUR	GRAIN SIZE	TEXTURE	% BI*	% MU*	% CD*	% MEGACRYSTS	XENOLITHS	NOTES
BIOTITE-MUSCOVITE MONZOGRANITE										
DCmgHX	Halifax Monzogranite	light orange, buff	medium to coarse	megacrystic	4-6	0-2	0-1	<5	rare	
DCmgJSa	Joe Simon Monzogranite	orangish-pinkish-grey	fine to medium	equigranular to slightly porphyritic	4-6	1-3	0	0	none	typically equigranular with minor phenocrysts of quartz and alkali feldspar
DCmgJSb	Joe Simon Monzogranite Subunit "b"	orangish-pinkish-grey	fine to medium	porphyritic	4-6	1-3	0	0	none	same as DCmgJSa except porphyritic with 10-15% phenocrysts
DCmgJSc	Joe Simon Monzogranite Subunit "c"	light grey	fine to coarse	hypidio-morphic-granular	6-8	1-2	0	<5-10	none	similar to Lake George Monzogranite and in part has a poorly formed porphyry texture.
DCmgKL	Kerr Lake Monzogranite	light grey	fine to coarse	hypidio-morphic-granular	5-8	>1	1-3	5-20	rare	consistently contains cordierite
DCmgLG	Lake George Monzogranite	white-buff	medium to coarse	megacrystic	4-7	<1-3	<1	5-30	rare	similar to DCmgNR
DcmgNR	New Ross Monzogranite	white-buff	medium to coarse	megacrystic	4-7	<1-2	0-1	5-20	rare, few small ones	coarse grained; low biotite content; saussuritization of plagioclase
CmgNRa	New Ross Monzogranite Subunit "a"	pink, red	fine to medium	equigranular porphyritic	<2-6	1-2	<1	0-2	none	similar mineralogically to the New Ross Monzogranite; gradational contacts inferred between the units; low biotite content; locally areas with <2%; equigranular to porphyritic texture
DCmgNRb	New Ross Monzogranite Subunit "b"	white-buff	medium to coarse	megacrystic	4-7	<1-2	2-4	5-20	rare, few small ones	same as DCmgNR except with 2-4% large(0.5-2 cm) blocky cordierite
DCmgSP	Spectacle Lake Monzogranite	light grey, buff	coarse	megacrystic	4-6	0-1	<1	0	rare	coarse grain size and megacryst abundance
DCmgSPa	Springfield Monzogranite Subunit "a"	buff-orange	medium	equigranular	3-6	<1-3	<1	0	very rare	non-megacrystic, low biotite content, saussuritization of plagioclase
DCmgSPb	Springfield Monzogranite Subunit "b"	white-buff-orange	fine to medium	equigranular	3-7	1-4	0-1	locally a few	very rare	fine grained; low biotite content
DCmgWD	West Dalhousie Monzogranite	light-medium-grey	medium to coarse	hypidio-morphic granular	6->9	trace->1	0	20->30	common	peculiar texture with all megacrysts the same size; xenoliths are 'granitic looking' with same sized megacrysts.
BIOTITE-MONZOGRANITS										
DCmgS	Sherwood Monzogranite	light grey	fine to medium to coarse	seriate to megacrystic	6-8	1-2	<1	0-5	rare	displays very little alteration
DCmgWL	Whale Lake Monzogranite	light grey	fine to medium	seriate and slightly megacrystic	6-10	<1-1	0-1	5-20	some, generally <10 cm	massive; slightly megacrystic; small xenoliths
TRANSITIONAL GRANITE (MONZOGRANITE/GRANODIORITE)										
DCtg	Transitional Granite	light to dark grey	fine to coarse	megacrystic	10-13	<1	<1	3-15	common to abundant	high biotite content; megacrystic
DCtga	Transitional Granite Subunit "a"	light to dark grey	medium to coarse	megacrystic	10-12	<1	.5->1	10-15	some to common	consistantly coarse grained; highly megacrystic; 0.5->1% cordierite
DCtgb	Transitional Granite Subunit "b"	light to dark grey	fine to medium	porphyritic	9-11	<1	<1	0	some	fine- to medium-grained porphyry texture
DCtgBL	Boot Lake Transitional Granite	medium to dark grey,	fine to medium	porphyritic hypidio-morphic	10-20	trace	trace	<2-5	abundant	biotite-rich; variable texture from mafic porphyry to gneissic to 'granitic' and equi-granular; minor coarse grained material; parts of unit have penetrative fabric which is defined by aligned biotite.
DCtgCL	Cloud Lake Transitional Granite	light grey	fine to medium	hypidio-morphic granular	<12-14	trace	trace	<>2	common	very few small anhedral megacrysts; consistent texture; minor coarse grained material; xenoliths are often small (<10cm)
DCtgGL	Gasperaux Lake Transitional Granite	light grey	medium to coarse	hypidio-morphic granular	12-15	<1	<1	10-15	common	high biotite content and consistently coarser grained than DCtg
GRANODIORITE										
DCgd	Granodiorite	grey, bluish grey	medium to coarse	hypidio-morphic granular	13-15	<1	0	5-10	common	
MAFIC PORPHYRY										
DCmpmp	Mafic Porphyry	grey-black	fine	porphyritic	10-20	<1	0	variable	rare to abundant	very high biotite content; porphyritic texture

*BI = biotite
MU = muscovite
CD = cordierite


Limit of mapping, 1985.
Windsor
21 A/15
21 A/16
21A/10
21A/09
New Ross
Aylesford Lake
Gaspereau Lake
Lake George
Black River Lake
Cloud Lake
Scragg Lake
Panuke Lake
Upper Canoe Lake
Vaughan
Timber Lake
Sherbrooke Lake
Big Lahave Lake
Millet Lake
Chester
MAHONE BAY
New Germany
LG
GL
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IgML
CL
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NRa
NRb
S
LL
CA
SFa
SFb
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LO
WL
OL
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TCa
HX
A
B
A €OM
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gd
SP
---- gradational contact
—— sharp contact
0
5
10
km

NOTE All unit names are preceded by DCmg, DCtg or DClmg etc. Refer to legend for complete rock unit descriptions.

Figure 2. Generalized geology map of the 1986 field season; refer to Table 2 for legend

Table 2. Contributions to the understanding of the SMB

YEAR	TOPIC	REFERENCE*	REMARKS
1974-1980	Petrology and geochemistry	McKenzie and Clarke, 1975	Documentation of the differentiated nature (granodiorite to porphyry) of the SMB
	Phase relationships	Clarke et al., 1976	Documentation of magmatic andalusite
		Smith and Turek, 1976	Evaluation of tin potential of individual monzogranite plutons
		Abbott and Clarke, 1979	Hypothetical relationship in Al_2O_3-FeO-MgO system
		Chatterjee, 1980	Isotopic evidence for origin of SMB**
		Clarke and Halliday, 1980	Style and variety of mineralization in SMB
		Longstaffe et al., 1980	Oxygen and strontium
			Oxygen and strontium
	Regional compilation	Keppie, 1979	Compilation of previous mapping
1981-1985	Petrology and geochemistry	Allan and Clarke, 1981	Documentation of occurrence and origin of peraluminous minerals
		Muecke and Clarke, 1981	Constraints on geochemical evolution of SMB, REE evidence
		Clarke, 1981	Overview of the mineralogy of peraluminous granites
	Isotopic dating	Reynolds et al., 1981	^{40}Ar/^{39}Ar geochronology of granitoid rocks, geological evolution of the Meguma Zone
	Regional metallogeny Peraluminous granites	Chatterjee et al., 1982	Documentation and hydrothermal alteration attending U mineralization, Millet Brook deposit
	Role of leucogranites as Metal generators	Chatterjee and Muecke, 1982	Radioelement distribution and exploration implications in the SMB
	Hydrothermal alteration of the granitoid rocks	O'Reilly et al., 1982	Style of mineralization and origin of deposits in the New Ross area, SMB
	Similarity in metallogenic evolution between the Appalachians and Hercynian Europe	Chatterjee, 1983	Delineation of metallogenic domains, SMB and immediate environment
		Chatterjee et al, 1983	Contrasting leucogranites related to mineralization, the role of fluids
		Chatterjee and Strong, 1984a	Description and geochemistry of the East Kemptville deposit
		Chatterjee and Strong, 1984b	Hydrothermal alteration of granitoid rocks, Millet Brook deposit
		Chatterjee and Strong, 1985	Geochemical characteristics of the tin domain
		Chatterjee and Strong, 1985	Overview of chemical and mineralogical characteristics of mineralized granitoid rocks in Nova Scotia and Newfoundland
		Clarke and Chatterjee, 1985	Documentation of magmatic and post-magmatic processes
		Clarke and Muecke, 1985	Overview of petrology and geochemistry of SMB
		Clarke et al., 1985	Sm-Nd study of SMB and Cambro-Ordovician metasedimentary rocks
	Airborne radioelements survey data, petrochemistry and origin of SMB	Ford and O'Reilly, 1985	Indication of granophile element specialization and associated mineral deposits using airborne spectrometric survey data
	Chemical and mineralogical aspects of mineralized granitoid rocks in Nova Scotia and Newfoundland	Kontak and Corey, 1987	Documentation of occurrence of metasomatic peraluminous minerals (garnets, alumnosilicates) in SMB
	Petrology and geochemistry of the Musquodoboit Batholith	MacDonald and Clarke, 1985	First database on Musquodoboit Batholith with assessment of mineral potential
		Maillet and Clarke, 1985	Role of cordierite as a magmatic mineral in peraluminous granitoids
	New perspectives	Giles, 1985	Documentation and implications of major fault displacement of southern Nova Scotia granitoids
	Publications of Nova Scotia Department of Mines and Energy	MacDonald and Horne, 1985	Bedrock geology of SMB for NTS (1:50 0000) map sheets 11D/05, 11D/12, 11D/13, and 21A/16 (east half)
		Ham and Horne, 1985	
		Corey, 1985	
		MacDonald et al., 1985	
		Finck and Graves, 1985	Till and pebble data maps for NTS (1:50 000) map sheets 11D/05, 11D/12, 11D/13 and 21A/16(east half)
		MacDonald et al., 1986	Bedrock geology of SMB for NTS (1:50 000) maps sheets 21A/09, 21A/10, 21A/15 and 21A/16,(west half)
		Kontak, 1986	Preliminary 1:200 mapping of East Kemptvile Sn deposit with geochemistry
		Graves and Finck, 1986	Pleistocene mapping of SMB for NTS (1:50 000) map sheets 21A/09, 21A/10, 21A/15 and 21A/16
		O'Reilly, 1986	Geology of manganese mines
			Systematic mapping (1:50 000) of SMB with concurrent surficial mapping and studies of till mineralogy and geochemistry
	Current research of Nova Scotia Department of Mines and Energy	Nova Scotia Department of Mines and Energy staff	Deep drilling of granitoid rocks as part of Mineral Resources Research Drilling Program
1976-1980	Discoveries and exploration	Open File Reports of Nova Scotia Department of Mines and Energy	Pre-1974: total of 7 drillholes in SMB 1974-1982: more than 200 drillholes completed 1976: discovery of tin in southwestern Nova Scotia by Cuvier Mines Limited 1977: active exploration by Shell Minerals Incorporated discovered in veins in Cambro-Ordovician metasediments 1977-1978: uranium discovered in SMB by Esso Minerals Canada Limited active exploration at East Dalhousie depicting U mineralization similar to that in Massif Central 1977-1978: active exploration, Aquitaine discovery of Millet Brook deposit 1978: exploration with uranium emphasis, Shell Canada Resources Limited 1979: till geochemistry leads to discovery of tin of East Kemptville 1983-1985: active exploration in Musquodoboit Batholith by Billiton Canada Limited and Kidd Creek Mines Limited: discovery of significant tungsten mineralization

*abstracts not cited to conserve space; not intended to be a complete reference source.
**SMB = South Mountain Batholith

granodiorite to monzogranite. These compositions vary inconsistently over short distances, within and between outcrops, and therefore are not divisible into units based on field description. In many cases, the transitional granite and granodiorite can only be separated after systematic point counting.

Transitional granite is texturally variable as it is generally light to dark grey, medium- to coarse-grained, slightly to moderately megacrystic (2-15%) and contains 10-14% biotite, trace muscovite and trace cordierite. Xenoliths similar to those found in the granodiorite are common.

BIOTITE MONZOGRANITE

Biotite monzogranite visually resembles the granodiorite and transitional granite, however, the former is characterized by lower biotite content (7-10%) and may have minor muscovite and trace amounts of cordierite (although 1-4% in localized areas). These rocks plot consistently in the monzogranite field of the QAP diagram. Texturally, these rocks are fine- to coarse-grained (predominantly medium- to coarse-grained), may contain 2-20% megacrysts and have a local fine grained porphyry texture. Xenoliths similar to those found in the previous two categories are common but not abundant.

MEDIUM- TO COARSE-GRAINED MEGACRYSTIC 2-MICA MONZOGRANITE

The rocks are whitish grey to buff, pink and orange, medium- to coarse-grained, and generally highly megacrystic (15-50%). They contain 4-6% biotite, <1-3% muscovite and variable amounts of cordierite (trace-4%) and plot near the syenogranite side of the monzogranite field. Xenoliths are very rare. Slight to moderate pervasive hematization and saussuritization of plagioclase is characteristic of this unit. Volumetrically, this unit is the most abundant of the 2-mica monzogranite units (i.e. units 5-8).

FINE- TO MEDIUM-GRAINED EQUIGRANULAR 2-MICA MONZOGRANITE

Mineralogically these rocks are similar to the monzogranite of the previous unit and contain 4-6 % biotite, 1-4 % muscovite and minor cordierite. Slight to moderate pervasive hematization and saussuritization is also characteristic of this category. These rocks range from fine- to medium-grained equigranular to slightly porphyritic with limited areas of fine grained porphyry.

PORPHYRY

This unit is characterized by monzogranitic rock (usually 2-mica) with a fine grained groundmass containing phenocrysts of quartz, alkali feldspar, plagioclase, and local biotite and muscovite. This category is based primarily on texture as the rocks are mineralogically comparable to the previous two units, and may in some cases represent textural variations of those rocks. Xenoliths are very rare. Hematization and saussuritization are common.

INTRUSIVE SUITES

Intrusive suites comprise rocks of biotite-muscovite monzogranite (with minor syenogranite) composition but are divisible by the diversity of texture, grain size and mineralogy. Textures include equigranular, aplitic (saccharoidal), pegmatitic, seriate, hypidiomorphic granular, porphyritic and megacrystic. Grain sizes range from fine to coarse and mineral constituents include quartz, alkali feldspar, plagioclase, muscovite, biotite, cordierite and andalusite and other accessories. Several textural and compositional varieties may be observed in a local area and often within the same outcrop and therefore have been grouped into one unit.

LEUCOGRANITE AND LEUCOGRANITE SUITES

These rocks (predominantly monzogranite with minor syenogranite) are generally fine- to medium-grained, contain <2% total mafics (e.g. biotite) and have elevated contents of muscovite (i.e. >2%). Leucogranite suites display similar textural and compositional complexities to intrusive suites but have <2% total mafics.

Table 1 summarizes the individual features of the 36 map units encountered in the 1986 field area. These units have been grouped under 9 basic divisions with the most differentiated rocks at the top. The table also serves as a legend for the geology map in Figure 2.

FIELD RELATIONS

Previous studies (e.g. McKenzie and Clarke, 1975) indicated that the SMB consists of large areas of 2-mica monzogranitic and associated leucogranitic rocks (this paper, units 5-9), which have intruded earlier granitoids of predominantly biotite granodiorite and biotite monzogranite compositions (this paper, units 2-4). Although the authors have subdivided the rocks of the SMB into approximately 50 major map units, the relationship whereby 2-mica rocks intrude the 1-mica rocks of the batholith was not changed. Each division has different characteristics (Table 3).

Table 3. Summary of characteristic features of biotite, and biotite-muscovite granitic rocks

FEATURE	2-MICA GRANITOIDS	1-MICA GRANITOIDS
% muscovite	<1-4 % (primary and secondary)	trace (secondary)
% biotite	5-6 %	>10 %
xenoliths	rare to absent	common to abundant
alteration	common (hematization, cholorization, saussuritization)	fresh

Present mapping has outlined two centres of monzogranitic rocks (Fig. 2). The first centre forms a circular pattern (approximately 30 km x 40 km) which extends south and east from New Ross. This area, the New Ross Pluton (NRP), represents the western half of the New Ross-Vaughan Complex (NRVC) of McKenzie (1974) thought to extend from New Ross to Halifax (Keppie, 1979). However, recent mapping indicates the NRVC consists of two separate monzogranitic plutons, namely the NRP and the Halifax Pluton (MacDonald and Horne, 1986).

A second area of monzogranitic intrusion consists of a narrow, linear, northeast-southwest trending body extending approximately 70 km from north of Lake George on NTS map sheet 21A/15 southwest through map sheet 21A/10 to map sheet 21A/11. This monzogranite body is referred to as the Lake George-Springfield Monzogranite Suite (LGS) and encompasses the Lake George and Springfield Monzogranites of McKenzie (1974).

The following section is a detailed discussion of the LGS and NRP, and the host biotite granite.

LAKE GEORGE - SPRINGFIELD MONZOGRANITE SUITE

The Lake George - Springfield Monzogranite Suite (LGS) consists of two northeast-southwest trending linear-shaped monzogranite bodies separated by a highly sheared, fault-bounded wedge of transitional granite (Fig. 2). The linear geometry of the LGS is distinct from the more circular New Ross and Halifax monzogranitic plutons.

There are four distinct units within the LGS (Table 1). The following is a summary of the important features of these units.

LAKE GEORGE MONZOGRANITE (DCmgLG)

The Lake George monzogranite comprises approximately 70% of the exposed area of the LGS. It is a buff to pinkish grey, medium- to coarse-grained, megacrystic(?), biotite-muscovite monzogranite. The unit DCmgLG is characterized by hematized plagioclase cores and abundant small (0.5 x 2.5 cm) alkali feldspar phenocrysts (up to 35%) which are often too small to be termed megacrysts (generally >3 cm). Flow foliations expressed by phenocryst alignment may be developed but direction varies on a scale of several metres.

Muscovite decreases in abundance and size from the north (1-3%, 2-3 mm) to the south (often <1%, <1-2 mm). Within the southern region several areas of the rocks have a finer grained, poorly developed porphyritic texture which contrasts the more common usual hypidiomorphic-granular texture.

A finer grained phase of DCmgLG, presumably representing a chilled margin, exists along the northern contact (0.5-1.0 km wide) with the Meguma Group metasediments. A striking feature of the Lake George monzogranite (as well as other 2-mica monzogranites in the batholith) is the absence of xenoliths within the granitic body, specifically near the contact with the country rocks.

SPRINGFIELD MONZOGRANITE (DCmgSFa,b)

The Springfield "a" unit (DCmgSFa) is a medium grained, biotite-muscovite, equigranular monzogranite to leucocratic monzogranite which locally has up to 5% alkali feldspar megacrysts. The Springfield "b" unit (DCmgSFb) is a fine- to medium-grained, biotite-muscovite, equigranular to locally porphyritic monzogranite to leucocratic monzogranite which is mineralogically similar to Springfield "a".

Although there are no exposed contacts between the two units, lithologic change over short distances (approximately 10 m) and the rare presence of "b" (?) unit dykes within the "a" unit imply a younger age for "b". The overall relationship between the two units is unclear but similarity in texture, lack of megacrysts and spatial association suggests that they are textural equivalents.

Both units generally display slight to moderate hematization as well as intense hematization and limonitization developed locally along fractures.

In the East Dalhousie area both units host north-northwest trending quartz-greisen veins which contain polymetallic (predominantly Cu-Sn) mineralization. Several small uraniferous shear(?) zones with intense hematitic alteration crosscut the northern lobe of the Springfield monzogranite.

KERR LAKE MONZOGRANITE (DCmgKL)

The Kerr Lake monzogranite is a medium- to coarse-grained megacrystic biotite-muscovite-cordierite monzogranite. It is the only monzogranite in the central part of the SMB (within the study area) that consistently contains significant amounts (1-3%) of large (0.5-1.5 cm) blocky cordierite. The only other area with similar cordierite occurs within the New Ross monzogranite south of Sherbrooke Lake. A cordierite-rich (2-4%) zone of DCmgNR outcrops next to the granite/metasediment contact, implying that the cordierite may have formed by xenocrystic "seeding" as outlined in Maillet and Clarke (1986). The Kerr Lake monzogranite, however, is not close to the metasediment contact (at the present level of erosion) and does not contain abundant xenoliths, suggesting that the cordierite may be a magmatic phase(?).

The relationship of DCmgKL with the other monzogranitic rocks of the LGS is unclear. However, a chilled margin is developed near the contact with DCtg which indicates that DCmgKL is younger. Also a sharp contact is inferred between DCmgKL and DCtgGL. No chilled margin was noted in either unit even though outcrops of each unit can be traced to within one metre.

MURPHY LAKE POLYPHASE LEUCOGRANITE (DClgML)

The Murphy Lake Polyphase Leucogranite (DClgML) occurs as several discrete bodies throughout the northwestern part of 21A/15. Large rafts or roof pendants of DCmgLG, DCtg and DCtgGL within DCmgML suggests that it is one of the youngest granite units in the LGS.

Unit DClgML is unique within the SMB because of the textural heterogeneity and pegmatite-rich nature of the rocks (Table 1). Rocks are (1) white, grey, buff, pink and orange, (2) fine medium- and coarse-grained, and (3) aplitic, equigranular, seriate, porphyritic and pegmatitic. Mineralogy is basically quartz-alkali feldspar-plagioclase (albite?)-muscovite-biotite. Individual outcrops often exhibit several textural varieties one of which may be banding (mineral and textural) similar to that in large aplite and pegmatite dykes near Portuguese Cove (Jewkes, 1985).

The unique pegmatite-rich nature of DClgML indicates a granite system which has evolved a large volume of volatiles. The abundant small round pegmatite pockets (20-30 cm) may represent miarolitic cavities (Chatterjee, personal communication) which are common in epizonal granites (Hyndman, 1972). Unit DClgML may therefore represent a shallow level leucogranite that is younger than the surrounding granites and was emplaced after substantial unroofing of the rest of the SMB.

THE NEW ROSS PLUTON

The New Ross Pluton (NRP) consists of a suite of monzogranitic rocks which form a roughly circular lithologically zoned pluton. This concentric arrangement of the different granitoid phases comprising the pluton is evident in Figure 2 and the included cross-section A-B.

The marginal phase consists of a biotite-muscovite monzogranite, the New Ross monzogranite (DCmgNR); the core is a more mafic biotite monzogranite, the Sherwood monzogranite (DCmgS). The NRP is enveloped predominantly by the more mafic granitic rocks (granodiorite and transitional granite) and the Meguma Group rocks. A brief description of the rock units as encountered in the cross-section from A to B follows. Additional details of the units are outlined in the legend (Fig. 2).

GRANODIORITE (DCgd)

This light grey coarse grained, hypidiomorphic granular unit is the most mafic of the major granitic units, with 12-15% biotite and trace muscovite. Plagioclase and alkali feldspar megacrysts are common (5-15%). This unit is part of the larger mass of granodiorite mapped in the eastern portion of the SMB during the 1985 field season (Ham and Horne, 1986; Corey, 1986). In the Vaughan area, it hosts fracture-controlled uranium mineralization at the Millet Brook deposit.

MEGUMA GROUP METASEDIMENTS (COG)

These rocks are typical Meguma Group strata and comprise a large inlier (roof pendant) that occurs at the contact between the granodiorite and the monzogranitic units.

NEW ROSS "A" MONZOGRANITE (DCmgNRa)

The New Ross "a" monzogranite is a variable unit with a fine- to medium-grained groundmass and equigranular to porphyritic textures. The majority of this unit occurs along the northern margin of the NRP and is equigranular to slightly porphyritic. Other small bodies of DCmgNRa occur within the main body of the DCmgNR monzogranite, along the southern portion of the pluton and at contacts between DCmgNR and other units. Gradational contacts indicate that some areas of DCmgNRa are textural equivalents of DCmgNR.

The biotite content of this unit is generally 4-6%, although locally (e.g. along the northern margin of the NRP) the biotite content decreases to 2-3%. Portions of this unit have been formerly termed a leucomonzogranite and leucogranite (McKenzie, 1974).

Unit DCmgNRa is moderately to strongly pervasively hematized along the northern margin of the pluton where many of the polymetallic mineral occurrences are found (O'Reilly et al., 1982). During the 1986 field season several new mineral showings (U, F) were located within this unit (Fig. 3). In other areas intense local alteration of the finer grained phases may produce muscovite- (2-6%) and potassium-rich granites, episyenites and greisens which are associated with polymetallic mineralization (Fig. 3). Pervasive buff colouration of DCmgNRa is diagnostic.

NEW ROSS MONZOGRANITE (DCmgNR)

This medium- to coarse-grained biotite-muscovite monzogranite is the most abundant unit within the NRP. It is whitish grey to buff to orange, and contains biotite, muscovite and cordierite (Table 1). The greater percentage is moderately equigranular but may contain local alkali feldspar megacrysts (5-10%). This unit is compositionally and texturally similar to the Halifax Peninsula biotite-muscovite monzogranite (DCmgHX) of MacDonald and Horne (1986).

SHERWOOD MONZOGRANITE (DCmgS)

This fine- to medium- grained equigranular to seriate monzogranite with <10% alkali feldspar megacrysts forms the core of the NRP and is characterized by its higher biotite content (8-10%) and variable texture relative to the surrounding biotite-muscovite New Ross monzogranite. It is similar to the Harrietsfield biotite monzogranite (DCmgHF) which forms the core of a zoned pluton occurring on the Halifax Peninsula (MacDonald and Horne, 1986).

SPECTACLE LAKE MONZOGRANITE (DCmgSP)

This homogeneous unit is a buff, coarse grained monzogranite characterized by large (average 5-6 cm) alkali feldspar megacrysts (30-40%). It is mineralogically similar to the DCmgNR.

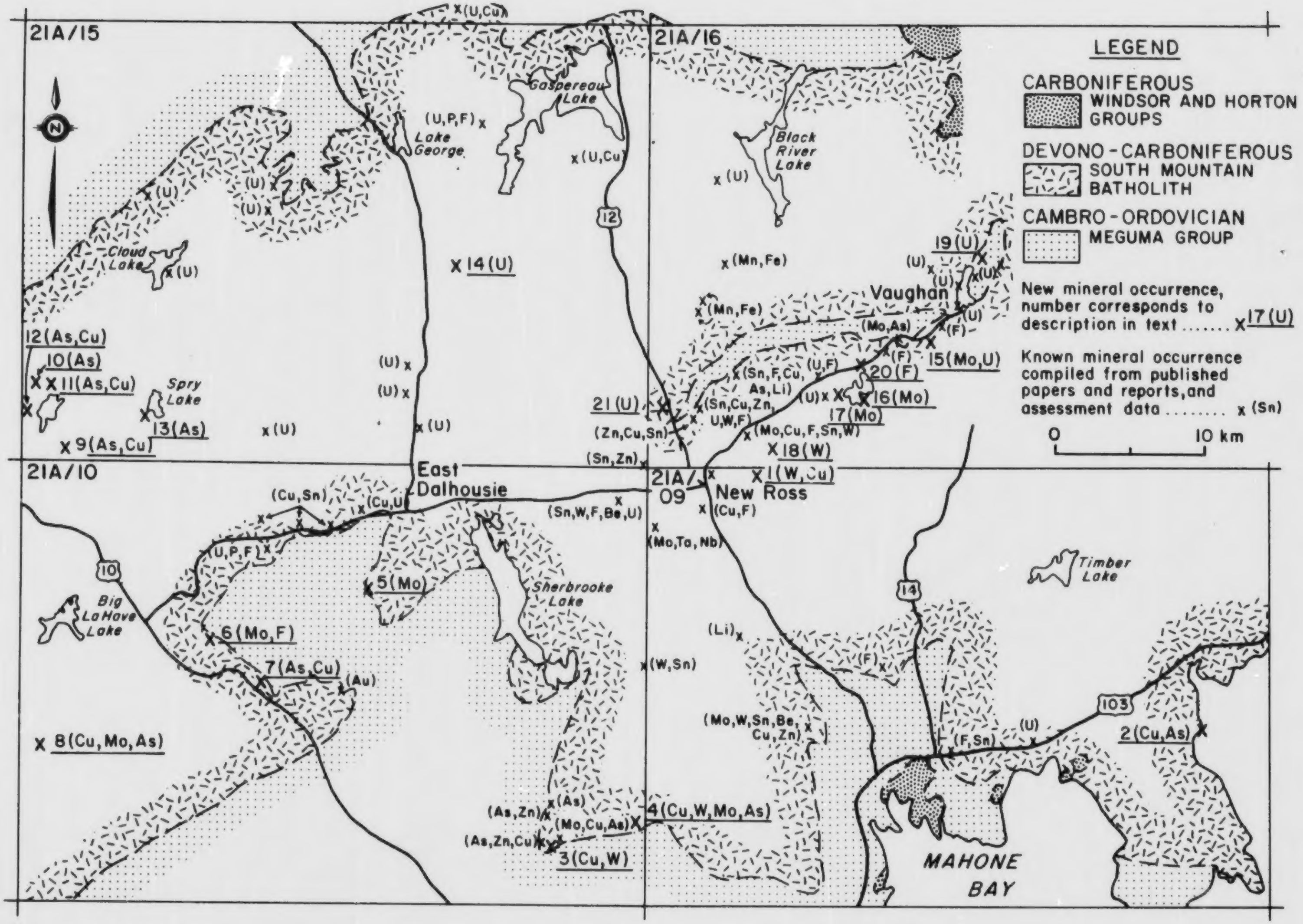
21A/15
21A/16
21A/10
21A/09
N
LEGEND
CARBONIFEROUS
WINDSOR AND HORTON GROUPS
DEVONO-CARBONIFEROUS
SOUTH MOUNTAIN BATHOLITH
CAMBRO-ORDOVICIAN
MEGUMA GROUP
New mineral occurrence, number corresponds to description in text .... x 17(U)
Known mineral occurrence compiled from published papers and reports, and assessment data .... x (Sn)
0
10 km
Lake George
Gaspereau Lake
Black River Lake
Cloud Lake
Spry Lake
Big LaHave Lake
Sherbrooke Lake
Timber Lake
MAHONE BAY
East Dalhousie
New Ross
Vaughan
12
10
14
103
1(W,Cu)
2(Cu,As)
3(Cu,W)
4(Cu,W,Mo,As)
5(Mo)
6(Mo,F)
7(As,Cu)
8(Cu,Mo,As)
9(As,Cu)
10(As)
11(As,Cu)
12(As,Cu)
13(As)
14(U)
15(Mo,U)
16(Mo)
17(Mo)
18(W)
19(U)
20(F)
21(U)
(U,Cu)
(U,P,F)
(U)
(Mn,Fe)
(Mo,As)
(F)
(Sn,F,Cu,As,Li)
(Sn,Cu,Zn,U,W,F)
(Mo,Cu,F,Sn,W)
(Zn,Cu,Sn)
(Sn,Zn)
(Cu,Sn)
(Cu,U)
(Sn,W,F,Be,U)
(Cu,F)
(Mo,Ta,Nb)
(Li)
(W,Sn)
(Mo,W,Sn,Be,Cu,Zn)
(F,Sn)
(Au)
(As,Zn)
(As)
(Mo,Cu,As)
(As,Zn,Cu)

Figure 3. Geological map of the study area indicating location of new and known mineral occurrences

TRANSITIONAL GRANITE (DCtg)

This unit (described earlier) appears in cross-section as a small body probably representing an inlier of the larger unit which comprises the envelope surrounding the NRP.

Field mapping resulted in several interesting observations regarding the lithologically zoned NRP:

. The northern portion of the NRP is comprised of a finer grained, equigranular to slightly porphyritic textural variation (DmgNRa) of DCmgNR which forms the majority of the zoned pluton. Many of these DCmgNRa bodies occur in proximity to the contact of the DCmgNR with other units.

. The core which is comprised of the Sherwood monzogranite (DCmgS) is more mafic than the surrounding DCmgNR and implies that the NRP has a reverse zonation.

. Small intrusive bodies of leucocratic monzogranite and leucogranite in particular are often associated with mineral occurrences (e.g. DClgBB).

BIOTITE GRANITE

Biotite granodiorite, transitional granite and biotite monzogranite generally host and form an envelope around later 2-mica monzogranitic bodies. Biotite monzogranite crosscuts 2-mica monzogranite, however, neither transitional granite nor biotite granodiorite intrude the 2-mica monzogranites.

Although the biotite granite envelope can be divided (on the basis of point counting) into three rock units, recognition in the field is difficult. Features such as biotite content, percentage of xenoliths and amount of megacrysts (generally alkali feldspar) are helpful in distinguishing units. In general the percentage of biotite decreases from granodiorite (12-14%) to transitional granite (9-12%) to biotite monzogranite (7-10%). The relative percentage of xenoliths tends to decrease in a similar way (i.e. abundant in the granodiorite to common in the biotite monzogranite). Megacrysts are predominantly alkali feldspar and thus greatly influence modal compositions (i.e. rocks of granodiorite composition will have a relatively low percentage (<10%) of megacrysts). Contact relationships involving these three categories are often difficult to establish since these rocks can display both sharp intrusive contact and apparent gradational contact relationships. Similar features were noted in recent mapping by MacLellan and Taylor (1987) in the Burnthill Granite of central New Brunswick.

Further work (e.g. whole rock and mineral chemistry) is required to better understand the intrusive history of the biotite granite.

HEMLOCK HILL COMPLEX

The Hemlock Hill complex is a large (5.5 km x 1.75 km) north-south trending, greyish brown to black gneissic inlier located in the eastern part of the SMB (Fig. 2). Two texturally and mineralogically similar, but smaller, inliers occurring immediately east of the Hemlock Hill Complex were also mapped as gneisses (Ham and Horne, 1986). Rocks of the Hemlock Hill Complex are amphibolite facies quartzofeldspathic rocks which are intensely deformed and exhibit gneissic banding (Fig. 4). Four fabrics were noted within some of these rocks (Fig. 5), as evidenced by refolded fold interference patterns, folded gneissosity with an associated foliation and superimposed alteration seams (Fig. 6). The mineral assemblage is quartz-plagioclase - alkali feldspar - biotite - muscovite - chlorite - cordierite (+/- sillimanite). Relict garnets, occurring commonly as pseudomorphic replacement by chlorite, are evident.

Past documentation (Faribault, 1931; Taylor, 1969; McKenzie, 1974) has suggested that these rocks are metasedimentary Meguma Group strata that have undergone granitization and contact metamorphism related to the intrusion of the SMB.

If this is true, then the following observations must be addressed:

. The large east-west trending inlier immediately west of the Hemlock Hill Complex is comprised of typical Meguma Group metagreywackes and metapsammites (Faribault, 1931; Taylor, 1969). These metasedimentary rocks do not exhibit the intensity of deformation, the same deformation history nor the compositional gneissic banding that is evident in the Hemlock Hill Complex and the two smaller inliers (unnamed) to the east. If these inliers were all Meguma Group strata with similar mineralogy and composition, similar deformation and thermal metamorphic histories should be observed.

. In other areas of the Province (particularly eastern Nova Scotia) where the Meguma Group rocks were subjected to multiple periods of deformation (i.e. Forest Hills, Guysborough; Keppie, 1983; O'Brien, 1983), gneissic banding is not evident.

. The style of polyphase deformation within these inliers is unlike that seen in the surrounding Meguma Group rocks.

Therefore it is puzzling that similar inliers (if Meguma Group metasediments) in proximity to each other should have undergone the same deformational and thermal history and yet responded so differently. The authors postulate that the intruding granite was not solely responsible for the observed deformation and certainly was not selective with regard to which inliers to affect. In conclusion, the authors suggest that the Hemlock Hill Complex and the two smaller inliers do not represent typical Meguma Group metasedimentary strata.

STRUCTURE

DALHOUSIE FAULT ZONE

A major northeast-southwest trending fault zone, termed the East Dalhousie Fault Zone

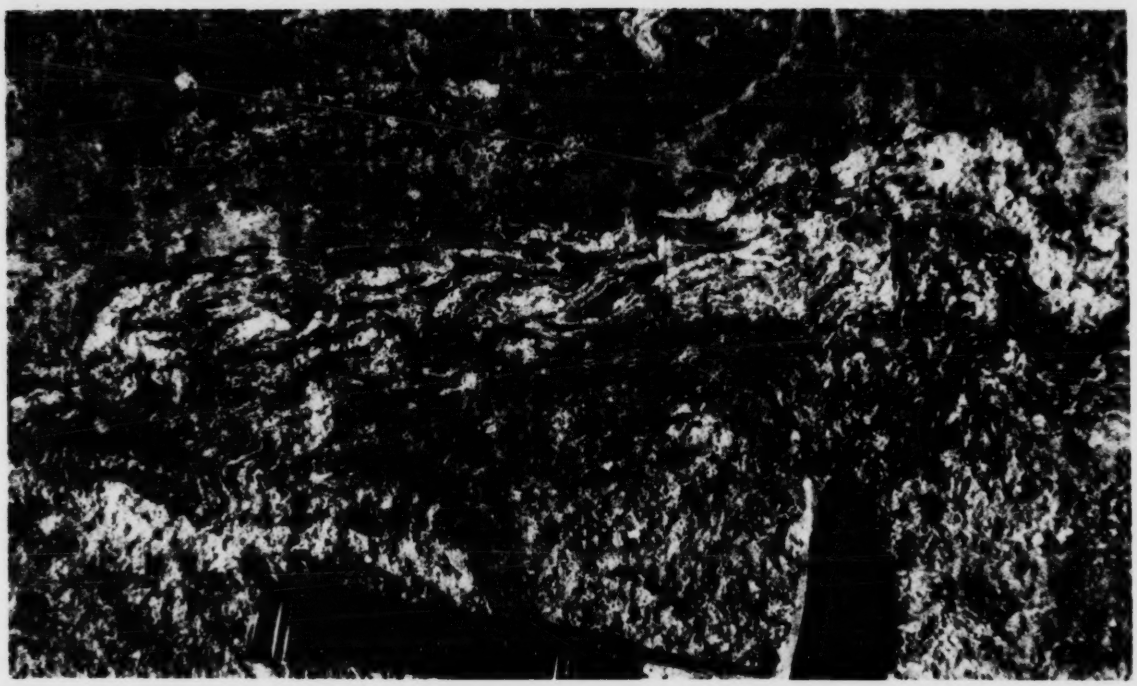

Figure 4. Compositional and gneissic banding within Hemlock Hill Complex; note folding of gneissic banding within the outcrop.

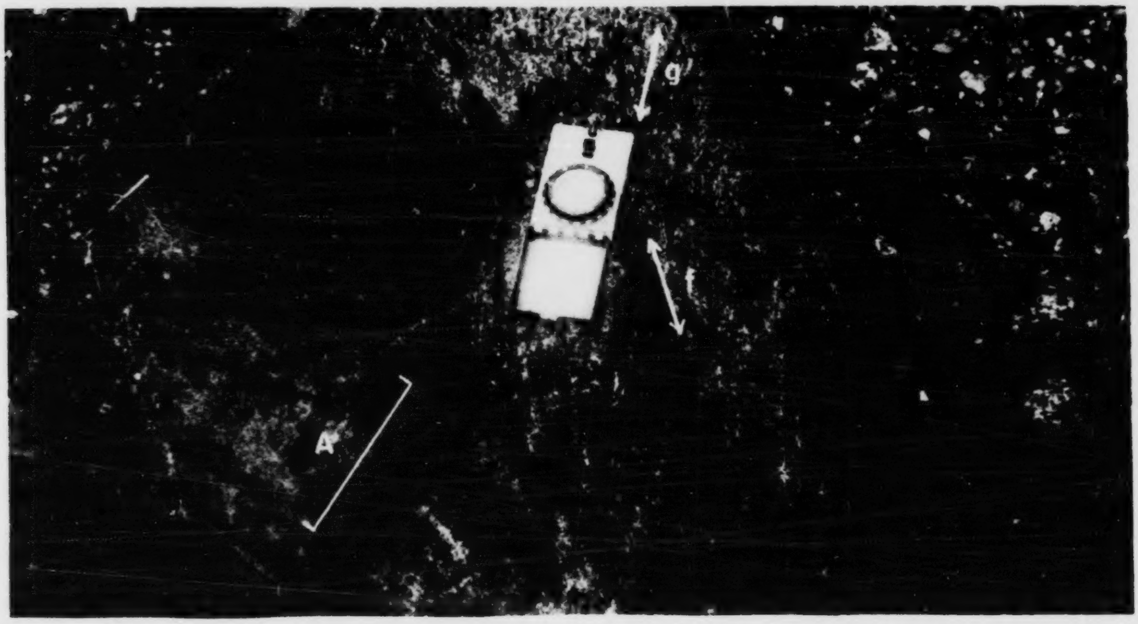

Figure 5. Gneissosity (parallel to compass; g) is cut by a foliation (parallel to string; f) which are both cut by a later alteration zone (A)

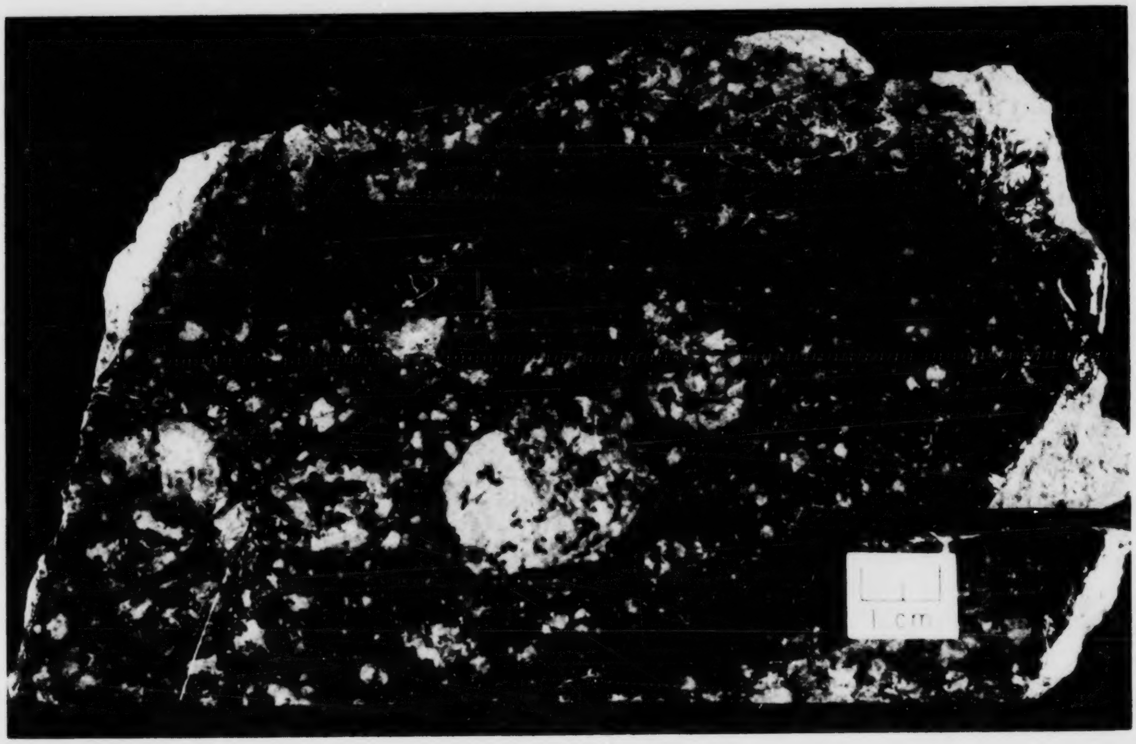

Figure 6. Fault gauge in transitional granite in the East Dalhousie Fault zone

(EDFZ), was first identified in 1982 by D. Rogers of Kidd Creek Mines. This structure is defined within NTS sheets 21A/10 and 21A/15. Evidence of faulting is primarily restricted to a narrow wedge of transitional granite (DCtg) which bisects two lobes of the LGS (Fig. 2). Although fault contacts occur between rocks of LGS and the wedge of DCtg shearing within the LGS is minimal. Macroscopic features in the zone include (1) intensely silicified, hematized and(or) chloritized fault gouge (<5->30 cm wide, Fig. 6); (2) narrow (1-2 cm) thinly banded mylonite occurring within the fault gouge, and (3) irregularly orientated chloritic stringers and fluid breccia dykes, which are generally accompanied by pervasive hematization, chloritization and silicification.

Orientations of shear features (slickensides, chloritic stringers, mylonitic fabrics) are often erratic and occasionally parallel the EDFZ. Minor displacement perpendicular to shear fabrics is common, suggesting episodic movement may have occurred. This implies that movement on the fault occurred primarily before the emplacement of the LGS. Indeed the linear nature of the LGS, which is coincident with the EDFZ, suggests the LGS intruded a previously existing linear structure within the DCtg. Relative movement along the EDFZ has yet to be established. However, two features indicate substantial movement:

- the presence of a large (.15 km x 2 km) slice of highly fractured metasedimentary rock within the fault bounded wedge of DCtg, approximately 4 km from the closest Meguma Group outcrop, and
- the host biotite granites of the LGS in the southwestern half of NTS map sheet 21A/10 are considerably different on either side of the LGS.

MEGACRYST ALIGNMENT

Megacrysts and, less commonly, elongate xenoliths define a weak lineation within the granitic rocks. This lineation is reflected by a well developed northeast-southwest megacryst orientation, which is best developed in the transitional granites of 21A/15 (DCtg, DCtgGL, DCtgCL). Megacryst alignment occurs in rocks with megacryst contents as low as 3% (Fig. 7). Megacryst alignment was previously noted by McKenzie (1974) and interpreted as representing primary igneous structures.

Although this lineation is consistent throughout the SMB, some areas display complex swirling patterns (jacuzzi structure). Such patterns were mapped in detail by Abbott (1982) within a biotite monzogranite at Chebucto Head.

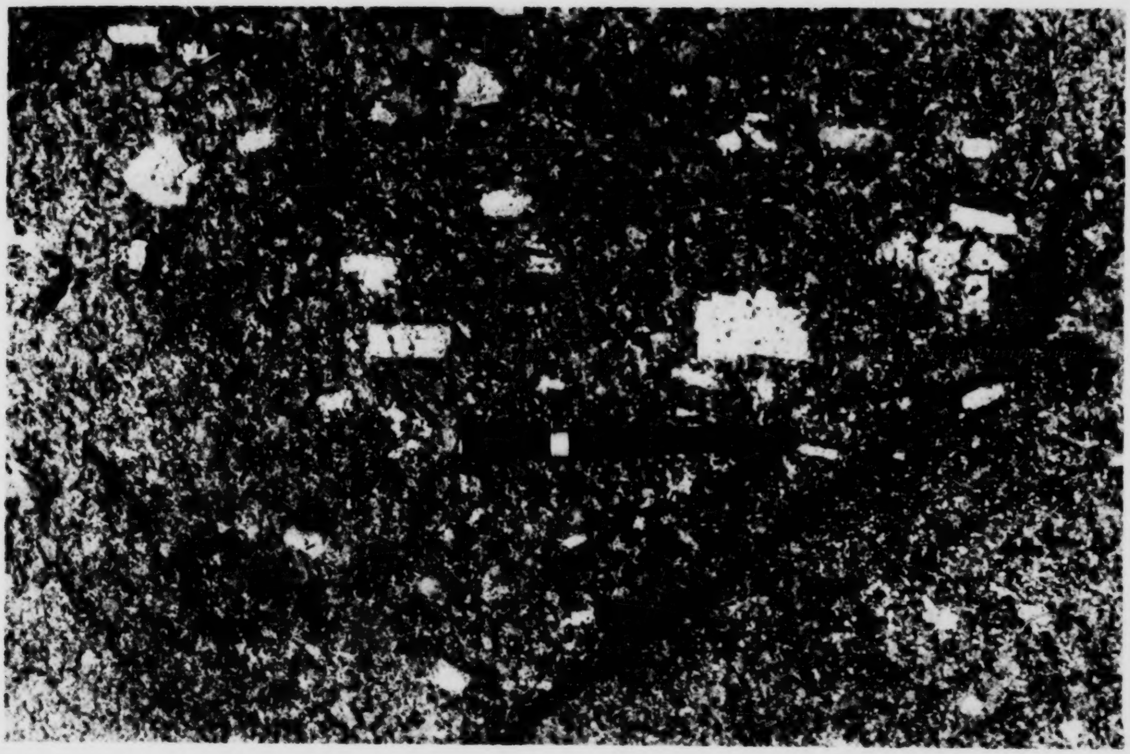

Figure 7. Foliation in megacryst-poor transitional granite of NTS sheet 21A/15

QUARTZ VEINS

A compilation of quartz vein orientations in the SMB indicates that most veins share a common 145° orientation (Fig. 8). It is evident from this data that the emplacement of all quartz veins in the SMB was controlled by a dominant regional stress. Either the stress field that controlled the emplacement of the veins endured the emplacement of all phases of the batholith, or all the quartz veins are of a single generation which postdates the SMB.

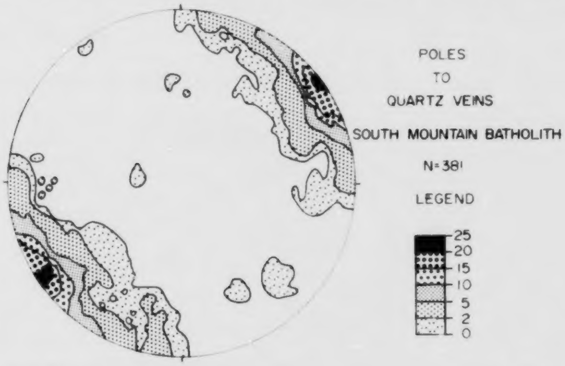

Figure 8. Density plot of poles to quartz veins (N=381) in the eastern half of the SMB; mineralized and barren veins included.

TECTONIC DEFORMATION

The Boot Lake Transitional Granite (DCtgBL) is the only unit observed to date that locally displays strong foliation defined by alignment of biotite crystals. Xenoliths are stretched in the plane of foliation and may have a long/short axis ratio of 20:1. Poorly developed gneissic banding (i.e. alternating leucocratic and melanocratic bands) may also accompany the foliation.

Similar foliations noted by Smitheringale (1973) within map sheets 21A/15(west) and 21A/14(east) were interpreted as being formed at the same time as the megacryst alignment. McKenzie (1974) referred to foliated granodiorites as "augen granodiorites" and suggested that they may postdate the monzogranite rocks.

MINERAL OCCURRENCES

Twenty new mineral occurrences have been discovered during the 1986 field season. Table 4 is a summary of the pertinent information for each of the new mineral occurrences and Figure 3 displays the locations of these new showings. Numbers beside each occurrence correspond to the descriptions in the table and are intended only

Table 4. Summary of new mineral occurrences for NTS map sheets 21A/09, 21A/10, 21A/15 and 21A/16(West)

#	Occurrence Name	NTS Sheet	Northing/Easting	Mineralization*	Mineralization Style(s)	Host Rock	Alteration	Remarks
1	Leville Road	21A/09	4955840/388470	cc, cr, wf	dissemination-pegmatitic	leucocratic porphyry	sercite	coarse disseminations (1 cm^2) of chalcocite altering to chrysocolla in leucoporphyry and pegmatite pods; very minor wolframite also observed in pegmatite pods
2	Fox Point	21A/09	4939100/416370	py, cp, as	sheeted greisen-bordered quartz veins	medium- to coarse-grained 2-mica monzogranite	quartz-muscovite greisen	<1-2 cm wide quartz-muscovite greisen veins containing finely disseminated sulphides
3	Otter Lake	21A/10	4931950/374900	py, cp, wf	quartz veins	biotite monzogranite	-	sphalerite-, arsenopyrite-bearing quartz muscovite greisens and albitite dykes in the area documented by Corey (1982)
4	Whale Lake	21A/10	4933640/380380	wf, cp, mo, as, bo, py	quartz veins	biotite monzogranite	quartz-muscovite sulphide rich-greisen	1 cm wide quartz vein with <2 cm greisen
5	Saturday Lake	21A/10	4948675/362900	mo	sheeted quartz veins	mafic porphyry	-	angular boulders; located at contact between Meguma Group rocks and biotite granite
6	Falkland Ridge	21A/10	4945500/353760	mo, fl, sp, py	greisen-bordered quartz veins	biotite "granite" (i.e. compositions from monzogranite to granodiorite)	quartz, muscovite, sulphide greisen	located at the contact between Meguma Group rocks and biotite granite
7	Dog Falls	21A/10	4942860/356500	as, cp, py	quartz vein	biotite "granite"	quartz-muscovite greisen	quartz vein (<7 cm wide) (150/83W)
8	Tommy Lake	21A/10	4938800/342760	cp, mo, as, py	greisen-bordered quartz veins	leucocratic monzogranite	quartz-muscovite greisen	similar to Alton Road Copper mine and East Dalhousie tin showing (MacGillivray, 1982)
9	Scragg Lake "A"	21A/15	4957430/344630	py, as, cp, to	greisen-bordered quartz veins	biotite monzogranite	muscovite greisen	15 small (<1 cm wide) veins over 7 m with up to 2 cm of greisen development
10	Scragg Lake "B"	21A/15	4961800/342940	py, as, to	quartz vein	fine- to medium-grained 2-mica monzogranite	muscovite greisen (<0.5 cm)	3 small quartz veins (<1 cm wide) (164/69W)
11	Scragg Lake "C"	21A/15	4961730/343700	py, as, cp, bo	disseminated through greisen	leucocratic porphyry	muscovite greisen	angular boulders
				py, as, cp, to	greisen-bordered quartz veins	biotite monzogranite	muscovite greisen	angular boulders; miarolitic cavities (<3 cm diameter) occur in greisen
12	Scragg Lake "D"	21A/15	4960640/341950	as, py, cp, bo	greisen-bordered quartz veins	2-mica monzogranite	muscovite greisen	10 small (<2 cm wide) veinlets over several metres
13	Spry Lake	21A/15	4959730/349840	as, py	quartz vein	biotite monzogranite	-	1 small quartz vein (1-2 cm width)
14	Kerr Lake	21A/15	4968760/370150	au, tb, cp, ma, az, bo, py	quartz vein with associated pods of greisen; disseminated within host rock; fractures	fine grained 2-mica monzogranite dyke	muscovite greisen	vein type uranium mineralization; no shearing
15	Conrad Road	21A/16	4963875/398950	mo, fl	fracture-fillings	fine- to medium-grained 2-mica monzogranite dyke	-	greisen pods and pegmatitic segregations common within outcrop
16	South Canoe Lake #1	21A/16	4960470/395090	mo, fl	pegmatitic	leucogranite porphyry	-	molybdenite as fine disseminations (<3 mm); fluorite along 125°-140° trending fractures
17	South Canoe Lake #2	21A/16	4960640/393350	mo	disseminations	aplite dyke	muscovite greisen; kaolinite	45 cm wide dyke; abundant quartz and greisen veins within outcrop
18	Round Lake	21A/16	4957040/389130	wf	disseminations	fine grained leucogranite	sericite greisen	small blades of wolframite (<2 mm)
19	Falls Lake River	21A/16	4969130/402560	au(?)	fractures	fine grained 2-mica monzogranite dykes	-	dykes hosted by a gneissic roof pendant; elevated radiometric response in fractures
20	Harriston	21A/16	4956200/383940	au, tb	fractures	fine- to medium-grained 2-mica monzogranite	hematite	-
-	New Ross-Vaughan Road	21A/16	several locations along New Ross-Vaughan road	fl	fractures; disseminations	fine- to medium-grained 2-mica monzogranite	hematite, muscovite greisen	numerous fluorite occurrences at Leminster and Canoe Lake (O'Reilly et al., 1982)

*abbreviations: au=autunite; as=arsenopyrite; az=azurite; bo=bornite; cc=chalcocite; cp=chalopyrite; cr=chrysocolla; fl=fluorite;
ma=malchite; mo=molybdenite;py=pyrite; sp=sphalerite; tb=torbernite; to=tourmaline; wf=wolframite

for use in this report. Several new fluorite occurrences which were located along the New Ross Vaughan road are not numbered in the table and the figure. To display the overall pattern of mineralization known mineral occurrences (compiled from published reports) and assessment data also appear on Figure 3.

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CUMBERLAND BASIN PROJECT - AN UPDATE*

R. C. Boehner, R. J. Ryan and D. C. Carter

INTRODUCTION

The Cumberland Basin is a large (3600 km^2) Carboniferous structural basin in northern Nova Scotia and southeastern New Brunswick (Fig. 1). The basin contains over 7000 m of dominantly continental clastic sedimentary rocks with one major succession of evaporitic-marine strata (Boehner et al., 1986a). The basin fill ranges in age from Devono-Carboniferous to Early Permian and was deposited north of the Cobequid Highlands Massif and south of the Caledonia Highlands Massif following the Acadian Orogeny.

STRUCTURE

The internal structure of the basin is a synclinorium with two en echelon diapiric anticlinal structures, the Claremont (Malagash) and the Minudie Anticlines (Figs. 1 and 2). The intervening Wallace Syncline contains several isolated evaporite diapiric structures. Major synclines include the Athol Syncline, the Tatamagouche Syncline and the Dorchester Syncline north of the Minudie Anticline. The east-west folding is complicated by subparallel longitudinal and transverse faults with similar orientations to the Glooscap Fault System (Minas Geofracture). The nature of these faults in the deep subsurface is unclear.

Onlap of younger strata at the basin margins limits exposure of pre-Namurian strata. The pre-Namurian strata are exposed in the axial areas of the diapiric anticlines and the domes. Seismic surveys and a few deep petroleum exploration wells have established the occurrence of 1000 - 2000 m of Horton and Windsor Group rocks at depth within the basin. Remnants of Late Devonian - Early Carboniferous felsic and mafic volcanics, fanglomerates, sandstones and siltstones of the Fountain Lake Group occur along the basin margin and beneath the Carboniferous onlap unconformity at the eastern and western end of the Cobequid Highland Massif.

The area has a long history of coal and salt mining as well as building stone production. Until the turn of the century, there was a small but active copper mining industry in the area. The Cumberland Basin contains numerous sediment-hosted metallic mineral occurrences of Cu-Pb-Zn-Ag-Au-U mineralization. Nonmetallic mineral resources include barite, celestite, salt, potash and limestone. Native sulphur has recently been recognized in the Pugwash mine (Carter, this volume) and new development work has been undertaken at the Beckwith celestite prospect and the Dewar Hill limestone property near Pugwash.

ACTIVITIES

The varied activities of Nova Scotia Department of Mines and Energy (NSDME) project staff during the past year include:

1. field mapping of the Cumberland Basin (Ryan and Boehner) that continued west of the area as described in Boehner, Ryan and Carter (1986b); major rock units previously recognized continue into the new area and mapping is essentially complete within NTS map sheet 11E;
2. detailed underground mapping of the Canadian Salt Company Limited Pugwash Mine by D. C. Carter (see D. C. Carter, this volume);
3. stratigraphy and exploration potential of the Windsor Group by R. C. Boehner;
4. diamond-drilling for Carboniferous stratigraphy and mineral potential information near The Falls on the south border of the Tatamagouche Syncline as carried out by R. J. Ryan;
5. contributions to major international symposia including Sediment-Hosted Stratiform Copper Deposits held in conjunction with the Geological Association of Canada Annual Meeting in Ottawa, Ontario (see Ryan et al., in press(b)) (R. J. Ryan and R. C. Boehner) and the Basins of Eastern Canada and Worldwide Analogues Symposium held in Halifax, Nova Scotia (Ryan et al., in press(a); Boehner et al., 1986a; Boehner, 1986a) (R. C. Boehner, D. C. Carter and R. J. Ryan).

Preliminary results from this activity are outlined in subsequent sections.

SEDIMENTATION AND TECTONICS

Three allocycles have been recognized within the Middle Devonian and Early Permian strata of the Cumberland Basin (Ryan et al., in press(a)). These are the Mid-Devonian to Namurian, the Namurian to Westphalian A and the Westphalian D to the Early Permian. Each of these megasequences records a decelerating subsidence rate. An initial period of uplift of the highlands and rapid subsidence of the adjacent basin resulted in the deposition of coarse fanglomerates locally at the basin margins (Ryan et al., ibid). These coarse marginal deposits are succeeded by a transition to fluvial, lacustrine and, in the case of the Windsor Group, marine basin fill of widespread extent which may

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

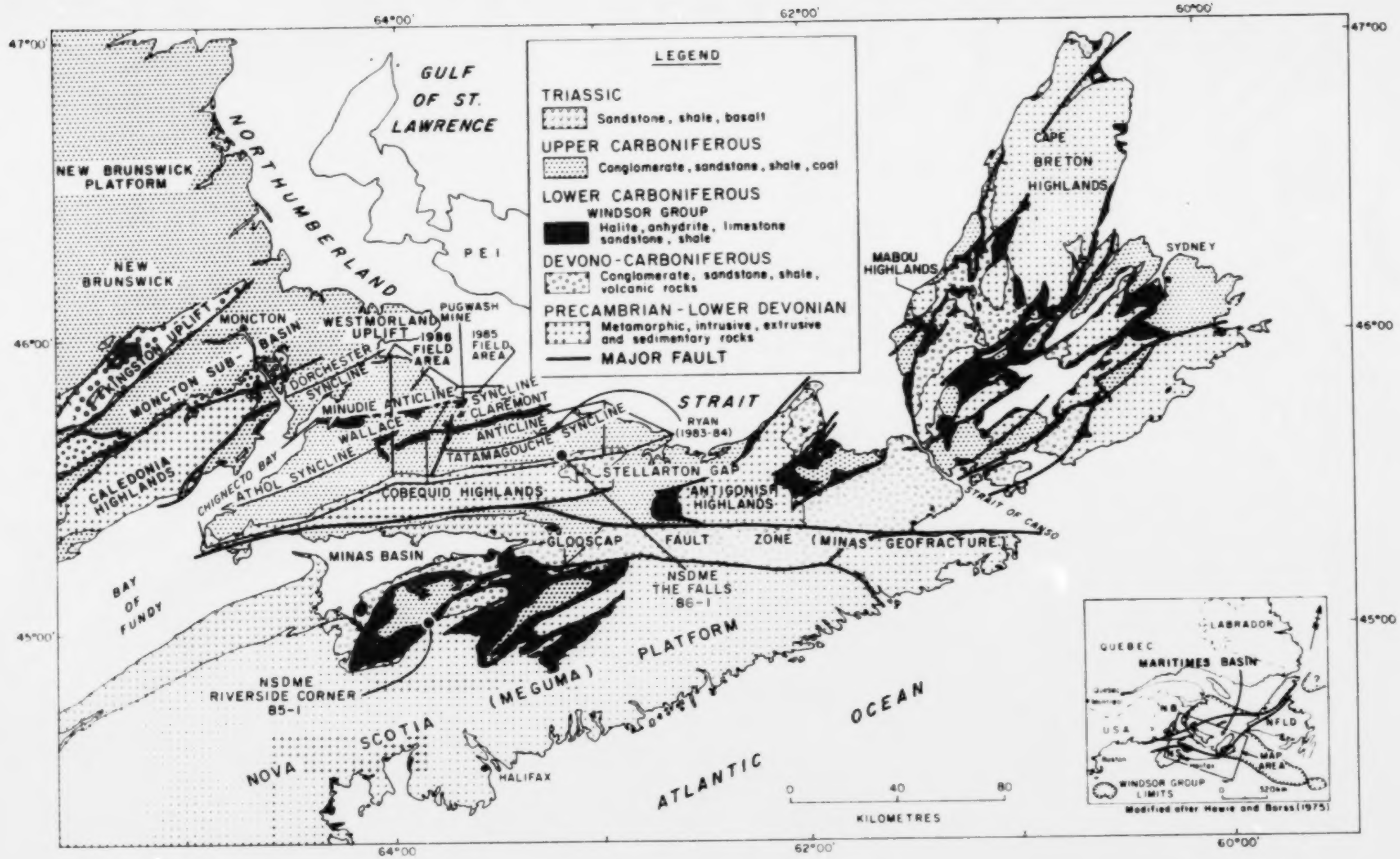
LEGEND
TRIASSIC
Sandstone, shale, basalt
UPPER CARBONIFEROUS
Conglomerate, sandstone, shale, coal
LOWER CARBONIFEROUS
WINDSOR GROUP
Halite, anhydrite, limestone sandstone, shale
DEVONO-CARBONIFEROUS
Conglomerate, sandstone, shale, volcanic rocks
PRECAMBRIAN - LOWER DEVONIAN
Metamorphic, intrusive, extrusive and sedimentary rocks
MAJOR FAULT
64°00'
62°00'
60°00'
47°00'
46°00'
45°00'
GULF OF ST. LAWRENCE
NORTHUMBERLAND
STRAIT
PEI
NEW BRUNSWICK PLATFORM
NEW BRUNSWICK
KINGSTON UPLIFT
MONCTON SUB-BASIN
MONCTON
CALEDONIA HIGHLANDS
WESTMORLAND UPLIFT
PUGWASH MINE
1986 FIELD AREA
1985 FIELD AREA
DORCHESTER SYNCLINE
MINUDIE ANTICLINE
SYNCLINE
CLAREMONT ANTICLINE
WALLACE SYNCLINE
TATAMAGOUCHE SYNCLINE
CHIGNECTO BAY
ATHOL SYNCLINE
COBEQUID HIGHLANDS
RYAN (1983-84)
STELLARTON GAP
ANTIGONISH HIGHLANDS
MABOU HIGHLANDS
CAPE BRETON HIGHLANDS
SYDNEY
STRAIT OF CANSO
GLOOSCAP FAULT ZONE (MINAS GEOFRACTURE)
MINAS BASIN
BAY OF FUNDY
NSDME THE FALLS 86-1
NSDME RIVERSIDE CORNER 85-1
(MEGUMA) PLATFORM
NOVA SCOTIA
HALIFAX
ATLANTIC OCEAN
0 40 80
KILOMETRES
LABRADOR
QUEBEC
MARITIMES BASIN
N.B.
NFLD
USA
MAP AREA
WINDSOR GROUP LIMITS
Modified after Howie and Barss (1975)

Figure 1. Regional geology and location map

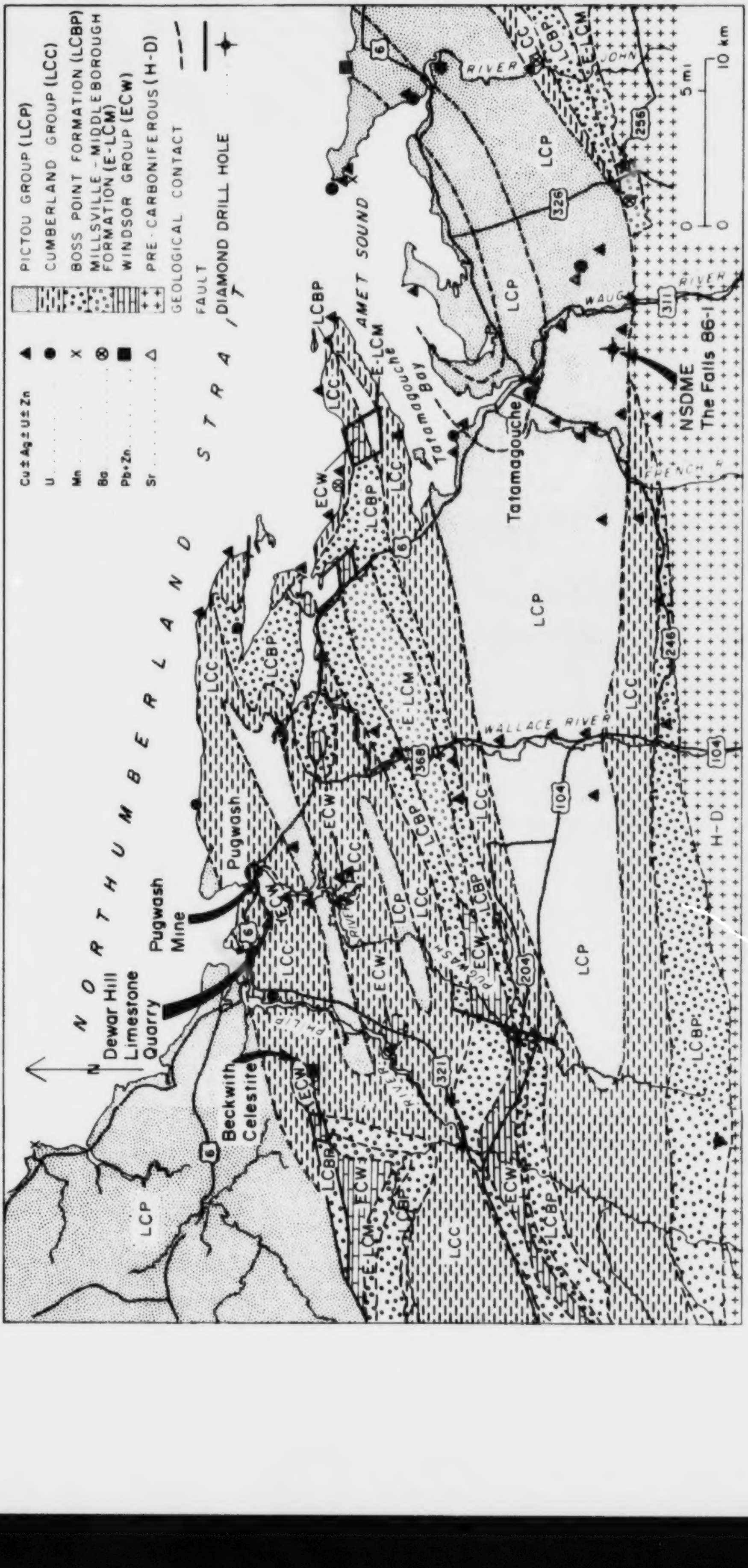
Cu±Ag±U±Zn
U
Mn
Ba
Pb+Zn
Sr
PICTOU GROUP (LCP)
CUMBERLAND GROUP (LCC)
BOSS POINT FORMATION (LCBP)
MILLSVILLE - MIDDLEBOROUGH FORMATION (E-LCM)
WINDSOR GROUP (ECw)
PRE-CARBONIFEROUS (H-D)
GEOLOGICAL CONTACT
FAULT
DIAMOND DRILL HOLE
N
NORTHUMBERLAND STRAIT
AMET SOUND
Tatamagouche Bay
Tatamagouche
Pugwash
Pugwash Mine
Dewar Hill Limestone Quarry
Beckwith Celestite
NSDME The Falls 86-1
WALLACE RIVER
FRENCH R.
WAUGH RIVER
JOHN RIVER
PHILIP RIVER
PUGWASH RIVER
LCP
LCC
LCBP
E-LCM
ECW
H-D
0 5 mi
0 10 km

Figure 2. Geology and mineral deposits of the eastern part of the Cumberland Basin, Nova Scotia

overstep the older basin fill units and the basement rocks.

The distribution of marginal alluvial fan deposits indicates that the Cobequid Highlands Massif was a fault-bounded wedge which tilted in different orientations through time in response to strike-slip movement along the faults.

Paleomagnetic surveys of the major stratigraphic units in the basin including the conglomeratic units are currently in progress by W. Morris in co-operation with the Geological Survey of Canada. These studies may assist in constraining the ages of the episodic fanglomerate deposition along the basin margins.

ECONOMIC GEOLOGY

Occurrences of Cu-Ag are abundant within the Pictou redbeds of the Cumberland Basin (Figs. 2 and 3). The Cu mineralization occurs as chalcocite with pyrite and bornite near the red to grey boundaries within the strata. The depth (up to 440 m) of the mineralization suggests it is not shallow supergene (<20 m) as proposed by Brummer (1958). The Canfield Creek prospect (300,000 tons of 1.2% Cu) demonstrates the potential for deeper and larger deposits of Cu than those previously described and locally exploited in the area.

The redbeds of the Cumberland Basin have a secondary (diagenetic) origin (Ryan et al., in press(b)). The reddening process was coincident with incursion of oxygenated groundwater deep into the basin during a period in which the water table was lowered. This major event probably occurred during the time interval represented by the Permian-Triassic unconformity.

Geochemistry of the tills (Stea et al., 1986) and stream sediments, as well as lithogeochemistry (Ryan et al., in press (b)) all suggest that there has been a depletion of Cu from the redbeds within the basin. It is therefore suggested that Cu-rich groundwater flowed into the basin within permeable sandstone units until it encountered reductants, which were either fine- to coarse-grained coalfield plant material and pyrite within channel lags at the base of the channel sandstone bodies, or basinal saline waters or brines.

Ryan et al. (in press(b)) suggest that extensive areas of geochemically low Cu values (negative anomalies) associated with redbeds containing numerous Cu occurrences delineate potentially good areas to explore for this type of mineralization. The common association of Ag and Au with these occurrences enhances their attractiveness as exploration targets.

Investigation of the Windsor Group in the area is severely hindered by very limited outcrop and structural complexity that is further complicated by evaporite solution collapse. The stratigraphic succession is fragmentary and nowhere complete. Significant potential may exist for exploration and development of limestone-dolomite and gypsum deposits especially near Pugwash, Oxford and Hansford. A preliminary examination of the Lime Kiln Brook area, located approximately 40 km west of Pugwash, indicates similar limestone to that currently being developed at the Dewar Hill Quarry, near Pugwash. Salt and potash potential is considerable (Boehner, 1986b), although structural complexity and stratigraphic uncertainly hinder exploration drilling activity.

STRATIGRAPHIC DRILLING

During the 1986 field season a drillhole, NSDME TF-86-1, was completed to a depth of 785.5 m (2,577 ft) near The Falls, Colchester County. The hole was drilled to evaluate the nature of stratigraphic onlap of Upper Carboniferous strata onto the Devono-Carboniferous and older basement rocks along the southern limb of the Tatamagouche Syncline. In addition, the drilling was designed to test several economic mineral models applicable to the Carboniferous geology in the area.

DRILLHOLE STRATIGRAPHY

Interbedded red and grey sandstones and mudstones of the Pictou Group (Westphalian D - Stephanian) were intersected from onset to a depth of 373.4 m followed by red polymictic fanglomerates of the Falls Formation and(or) the Millsville Formation (Late Devonian and(or) Namurian) to 785.5 m.

MINERALIZATION

Abundant pyrite, occurring sporadically (up to 1%) over 1 m intervals, and traces of chalcocite mineralization are present within grey carbon-rich sandstones of the Pictou Group from 259 to 297 m.

DISCUSSION

The results indicate that the Riversdale and Cumberland Group strata are probably overstepped in the vicinity of the drillhole, and the Late Carboniferous Pictou Group strata lie directly upon the Late Devonian(?) Falls Formation. Although no significant economic mineralization was found, the trace amounts demonstrate the potential for mineralization within coeval beds in the Tatamagouche Syncline area to the north. High resolution seismic survey data from this area are currently being evaluated by D. Bromley of Geological Survey of Canada.

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1986a: The role of evaporities in the structural development of Carboniferous basins in Nova Scotia; Abstract in Basins of Eastern Canada and Worldwide Analogues Symposium, Programme with Abstracts, Atlantic Geoscience Society, p. 24.

1986b: Salt and potash resources in Nova Scotia; Nova Scotia Department of Mines and Energy, Bulletin No. 5, 346 p.

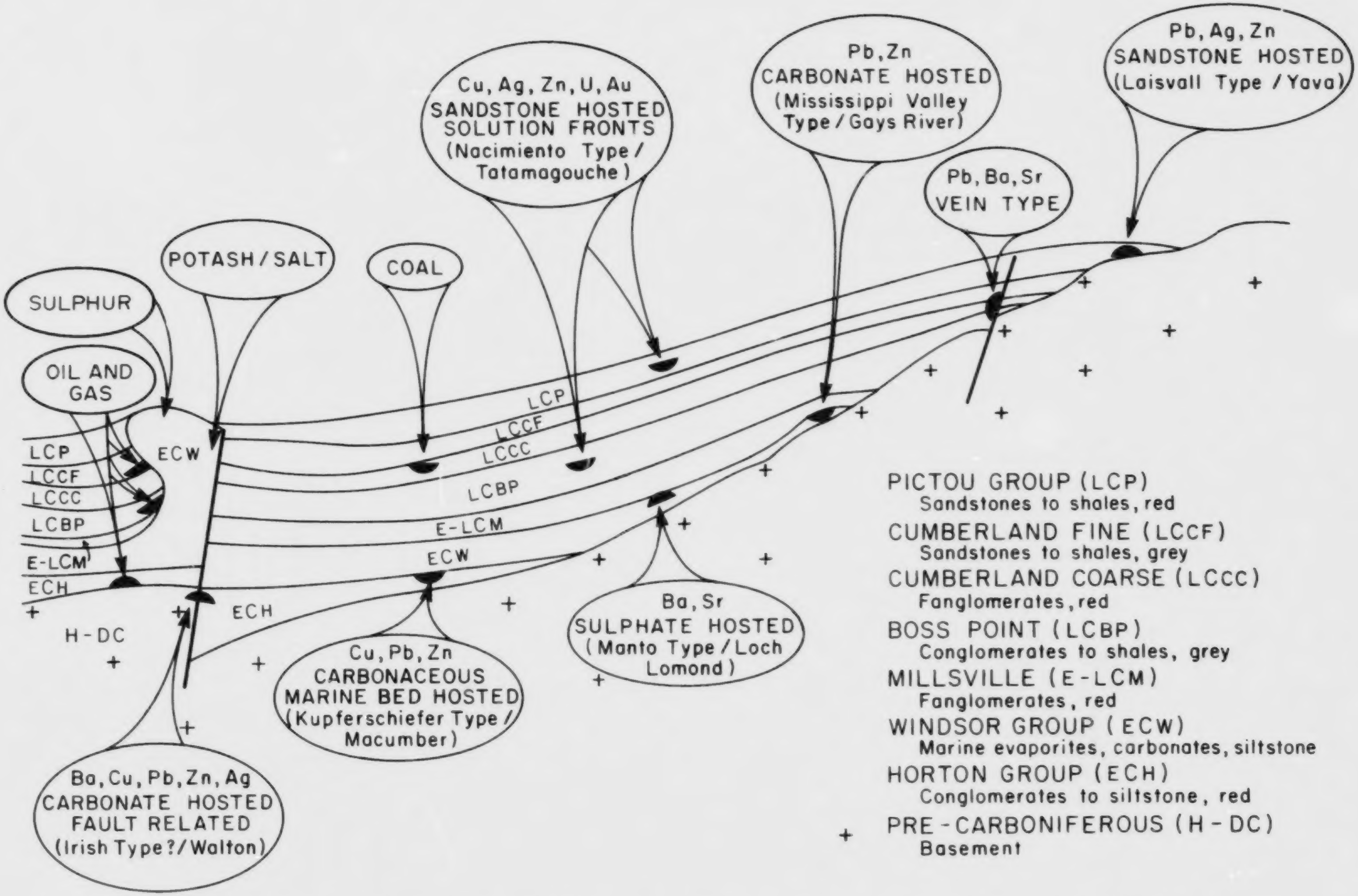
Pb, Ag, Zn
SANDSTONE HOSTED
(Laisvall Type / Yava)
Pb, Zn
CARBONATE HOSTED
(Mississippi Valley
Type / Gays River)
Cu, Ag, Zn, U, Au
SANDSTONE HOSTED
SOLUTION FRONTS
(Nacimiento Type /
Tatamagouche)
Pb, Ba, Sr
VEIN TYPE
POTASH / SALT
COAL
SULPHUR
OIL AND
GAS
LCP
LCCF
LCCC
LCBP
E-LCM
ECH
ECW
H-DC
Cu, Pb, Zn
CARBONACEOUS
MARINE BED HOSTED
(Kupferschiefer Type /
Macumber)
Ba, Sr
SULPHATE HOSTED
(Manto Type / Loch
Lomond)
Ba, Cu, Pb, Zn, Ag
CARBONATE HOSTED
FAULT RELATED
(Irish Type? / Walton)
PICTOU GROUP (LCP)
Sandstones to shales, red
CUMBERLAND FINE (LCCF)
Sandstones to shales, grey
CUMBERLAND COARSE (LCCC)
Fanglomerates, red
BOSS POINT (LCBP)
Conglomerates to shales, grey
MILLSVILLE (E-LCM)
Fanglomerates, red
WINDSOR GROUP (ECW)
Marine evaporites, carbonates, siltstone
HORTON GROUP (ECH)
Conglomerates to siltstone, red
+ PRE-CARBONIFEROUS (H-DC)
Basement

Figure 3. Diagrammatic representation of known and potential mineral and energy resources setting

Boehner, R. C., Calder, J. H., Carter, D. C., Donohoe, H. V., Jr., Ferguson, L., Pickerill, R. K. and Ryan, R. J.
1986a: Carboniferous-Jurassic sedimentation and tectonics: Minas, Cumberland and Moncton Basins, Nova Scotia and New Brunswick; Atlantic Geoscience Society, Special Publication No. 4, 122 p.

Boehner, R. C., Ryan, R. J. and Carter, D. C.
1986b: Cumberland Basin Project - A progress report; in Mines and Minerals Branch, Report of Activities, 1985, ed. J. L. Bates; Nova Scotia Department of Mines and Energy, Report 86-1, p. 69-72.

Ryan, R. J., Calder, J. H., Donohoe, H. V., Jr. and Naylor, R.
in press(a): Late Paleozoic sedimentation, lithofacies variations and basin development of the Cumberland Basin and the Fundy Rift - St. Mary's graben of Eastern Canada; Canadian Society of Petroleum Geologists Special Publication.

Ryan, R. J., Boehner, R. C., Stea, R. R. and Rogers, P. J.
in press(b): Geology, geochemistry and exploration applications for the Permo-Carboniferous stratabound sediment hosted copper deposits of the Cumberland Basin, northern Nova Scotia, Canada; Stratabound Sediment Hosted Copper Deposits, Geological Association of Canada Special Publication.

Stea, R. R., Day, T. E. and Ryan, R. J.
1986: Till and bedrock Cu-Pb-Zn geochemistry in northern Nova Scotia and its metallogenic implications; in Prospecting in Glaciated Terranes, Institute of Mining and Metallurgy, p. 241-260.

WINDSOR GROUP STRATIGRAPHY AND STRUCTURE FROM THE RC85-1 DRILLHOLE NEAR KENNETCOOK, HANTS COUNTY, NOVA SCOTIA*

D. C. Carter

INTRODUCTION

The Riverside Corner 85-1 drillhole was located to examine the stratigraphy, structure and potash potential of the Clarksville salt occurrence in the Kennetcook River gravity low (Fig. 1; Boehner, 1986). The Clarksville occurrence is located 1.5 km north of Clarksville, which is 26 km northeast of Windsor, Hants County. The Kennetcook River gravity low is one of the largest (30 km x 6 km) gravity anomalies in Nova Scotia (Boehner, ibid) and is virtually unexplored. This 30 mgal Bouguer gravity low (Fig. 1) parallels the regional strike of Carboniferous sedimentary rocks in the area. Potential for salt and potash is indicated by limited previous drilling, salt springs and scattered high bromine analyses. The reader is referred to the compilation by Boehner (ibid) and mineral assessment reports by Cominco (1981) for a detailed discussion of the exploration history and geophysical surveys of the area.

Figure 1 shows the simplified geology and outline of the gravity low in the Clarksville area. Pre-Carboniferous metasediments of the Meguma Group form the Rawdon Hills Highlands to the southeast. The highlands are onlapped by Horton Group conglomerate, sandstone and shale, Windsor Group marine limestone, gypsum and anhydrite, and Upper Carboniferous Scotch Village Formation sandstone and shale. All units, except the flat-lying Scotch Village Formation, strike generally northeast and dip steeply to the northwest. Outcrops of Windsor Group rocks are scarce, although karst topography is quite common. Large faults, together with steeply dipping beds, suggest that the area is structurally complex. The results of the drilling program have shown this to be the case.

RESULTS

Figure 2 shows a lithological log of the Riverside Corner drillhole and combines the lithological, geophysical and engineering data (Carter and Boehner, 1986). Identification of the Herbert River limestone marker was made visually. The location of fold axes were also made visually and later confirmed by the geophysical logs (see Carter and Boehner, ibid).

Bedrock was intersected at 52 m and to 132 m consists of medium to dark grey argillaceous mud and claystone and minor siltstone with white, pinkish grey to blue-grey gypsum and lesser anhydrite as veins, large nodules and clotted nodules. This lithology is typical of the Watering Brook Formation of the Canso Group (Boehner, 1986). The lower 17 m of this unit may be all or in part calcrete, exhibiting carbonate as well as sulphate nodules.

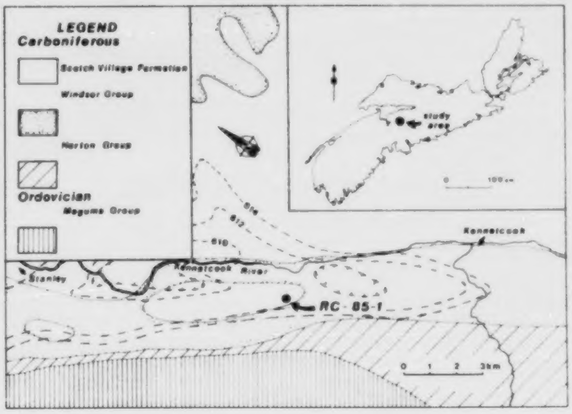

Figure 1. Location map of the Riverside Corner 85-1 drillhole showing simplified geology and outline of the Kennetcook River gravity low; Bouger gravity contours in mGal.

The underlying unit is designated the Scotch Village Formation (Pictou Group; Westphalian C) which has been determined previously, by Boehner (1986), to be stratigraphically higher than the Watering Brook Formation. If this is the case the contact must be faulted with Watering Brook strata thrust over Scotch Village strata. Placement of the fault is somewhat arbitrary over a 10 m zone which is sheared and brecciated.

The Scotch Village Formation was intersected from 132 to 458 m. The unit is steeply dipping (up to 80°) to overturned at the top and decreases to moderately dipping (35-45°) toward the base. The section consists of dominantly (~60%) red-brown conglomerate, sandstone, siltstone and mudstone with lesser (~40%) grey-green siltstone and mud-claystone. Clasts are moderately sorted, subrounded, average 1-2 cm (maximum 10 cm) diameter, resedimented sandstone and Windsor Group limestone in a calcareous sand matrix. Individual beds show normal to inverse grading, minor dewatering, and crosslamination features are interpreted as stratigraphic top indicators.

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

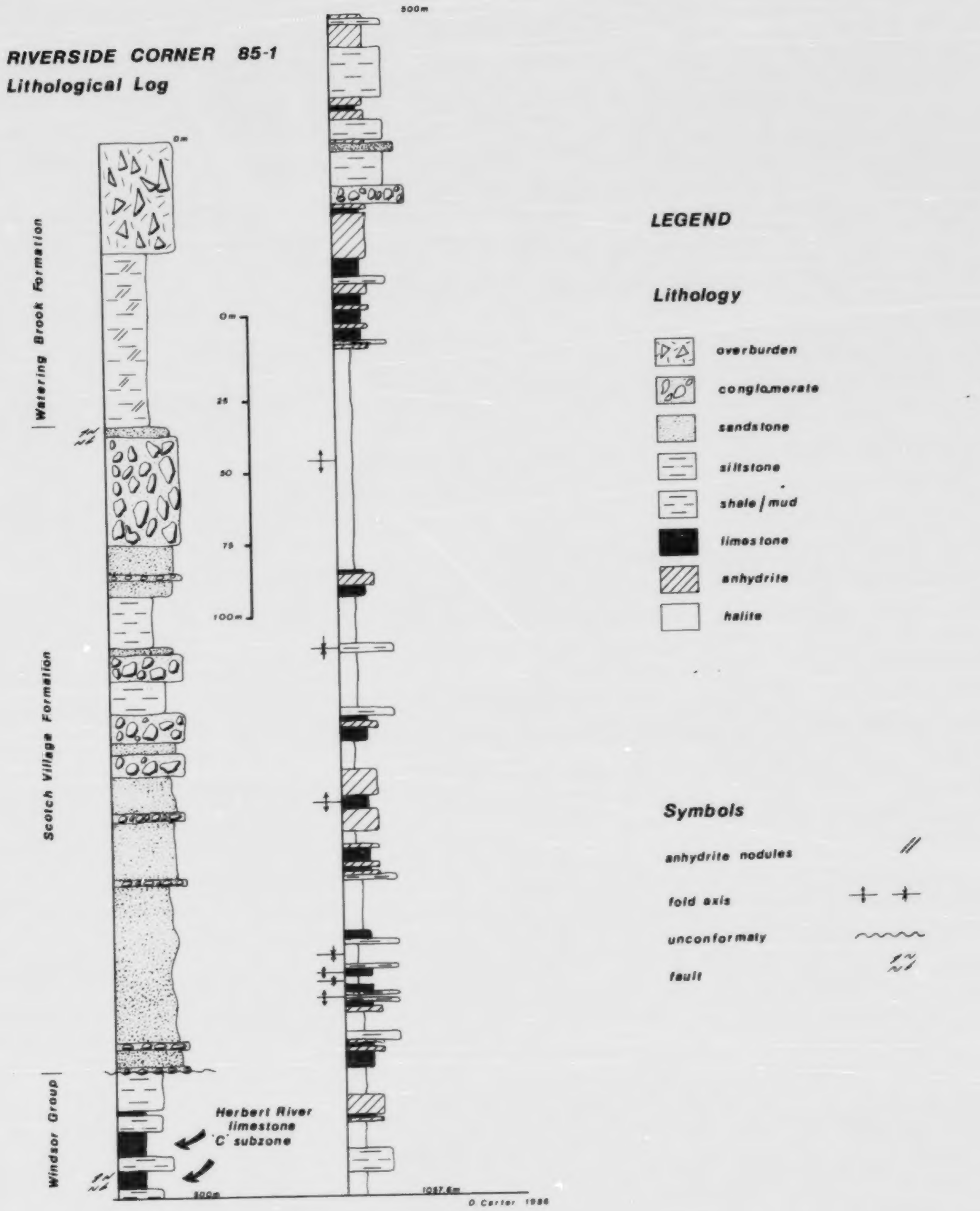
RIVERSIDE CORNER 85-1
Lithological Log
0m
500m
Watering Brook Formation
Scotch Village Formation
Windsor Group
0m
25
50
75
100m
Herbert River limestone 'C' subzone
500m
1087.6m
D Carter 1986
LEGEND
Lithology
overburden
conglomerate
sandstone
siltstone
shale / mud
limestone
anhydrite
halite
Symbols
anhydrite nodules
fold axis
unconformaty
fault

Figure 2. Lithological log of Riverside Corner 85-1; note fold repeat structures in the Windsor Group evaporate sequence.

The lower contact of the Scotch Village Formation is normally an unconformity with the Watering Brook Formation (Boehner, ibid). However, in this case the Watering Brook strata and the upper Windsor strata are absent or have been eroded and the Scotch Village Formation lies unconformably on Windsor Group strata. This explains the presence of numerous Windsor Group and(or) Canso Group limestone clasts in the Scotch Village conglomerates.

The Windsor Group was intersected at 434 m and continued to the end of the hole at 1057.6 m. Dips are moderate (45°) throughout the section. The basal C-subzone (Green Oaks Formation, Herbert River Limestone Member; Boehner, 1986) was intersected at two depths, 468-480 m and 486-495 m. Both intersections are stratigraphically right-way-up and separated by a small displacement reverse fault. The section from 458-657 m consists of limestone, dolostone and dolomitic siltstone, anhydrite, argillaceous mudstone and conglomerate. The latter two are the result of halite dissolution and collapse.

The 'top of salt' was intersected at 657 m after which the section is dominantly medium grained, clear, white to light grey halite with wispy inclusions, nodules and laminae of anhydrite with lesser amounts of massive to nodular anhydrite, dark grey to black algal and bioclastic limestone, and minor red-brown to grey-green mudstone. Minor red-orange acicular to fibrous vein-filling halite occurs locally throughout the interval. The section is complicated by at least seven fold structures (Fig. 2) as evidenced by repetition of carbonate-anhydrite packages. The lowest limb penetrated is overturned. This section is designated as B-subzone, MacDonald Road Formation (Boehner, obid).

The hole was terminated at 1057.6 m due to the prohibitive projected depth to the top of the main halite (A-subzone, Stewiacke Formation) and the limited depth capabilities of the drill rig.

DISCUSSION

The Windsor Group main halite, with its potential potash target, was not intersected due in part to the unusually thick section of Scotch Village Formation, structural complications (fold repetition and faulting) and consequently the depth to the 'top of salt'. The maximum capabilities of the drill rig were not reached due to engineering problems. The potash potential of the Kennetcook River gravity low remains significant based on a confirmed intersection of halite-bearing B-subzone Windsor Group strata and therefore warrants further examination.

Work is in progress under the supervision of Dr. R. Moore at Acadia University in Wolfville, Nova Scotia, to further document the carbonate stratigraphy intersected in the Riverside Corner drillhole. It is hoped that this work will be a useful tool in correlation of the stratigraphic nomenclature which has been applied to the Windsor and Shubenacadie sub-basins. These data combined with detailed surface mapping will be used to re-interpret the geology and structure of the area.

A re-interpreted model of the Kennetcook River gravity anomaly was completed (Nova Scotia Research Foundation Corporation, 1986) which incorporates the information obtained from RC-85-1. This work suggests that the "salt body" may be 3-4 km wide, about 28 km long and 1.85 km thick, and may occur within 300 m of the surface. Further, a second gravity structure, the Ross Brook anomaly, was identified to the northeast. The model predicts a body measures 3 km wide, 9 km long and 1.15 km thick with a depth to the top of 1 km (Nova Scotia Research Foundation Corporation, 1986).

SUMMARY

The Riverside Corner 85-1 drillhole was located and drilled by the Nova Scotia Department of Mines and Energy to examine the stratigraphy, structure and potash potential of the Kennetcook River gravity low. A structurally complicated evaporite sequence of Windsor Group was intersected. Although the Stewiacke Formation target was not reached, based on the geological and geophysical interpretation of the drilling results, the potash potential of the area remains significant.

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1986: Report on the drilling of Nova Scotia Department of Mines and Energy Riverside Corner 85-1; Nova Scotia Department of Mines and Energy, Open File Report 86-040, 12 p.

Cominco Limited
1981: Review and interpretation of existing aeromagnetic and gravity data and a report on ground gravity survey by Allan Spector and Associates Limited; Nova Scotia Department of Mines and Energy, Assessment Report 11E/04B 40-I-17(01).

Nova Scotia Research Foundation Corporation
1986: Interpretation of a gravity profile across the Windsor Kennetcook area of the Minas Subbasin of Nova Scotia; Nova Scotia Department of Mines and Energy, Open File Report 86-063, 16 p.

A THREE-DIMENSIONAL VIEW OF THE PUGWASH SALT DEPOSIT, CUMBERLAND COUNTY, NOVA SCOTIA

D. C. Carter

INTRODUCTION

The only demonstrable marine incursion into the Late Devonian-Early Permian Maritimes Basin (Boehner et al., 1986) occurred during Early Carboniferous (Visean) time and resulted in deposition of the Windsor Group evaporite, carbonate and clastic sequence. High-order evaporites (including salt and potash) were deposited in semi-isolated troughs or depressions throughout the basin (Anderle, 1980). Three potash deposits in southern New Brunswick are currently in the development stages (Roulston and Waugh, 1983). Salt is being mined from deposits at Nappan and Pugwash (Boehner, 1986) and the Magdelan Islands (Brisebois, 1981). Salt and potash also occur in southwestern Newfoundland (Anderle, 1982; Knight, 1983).

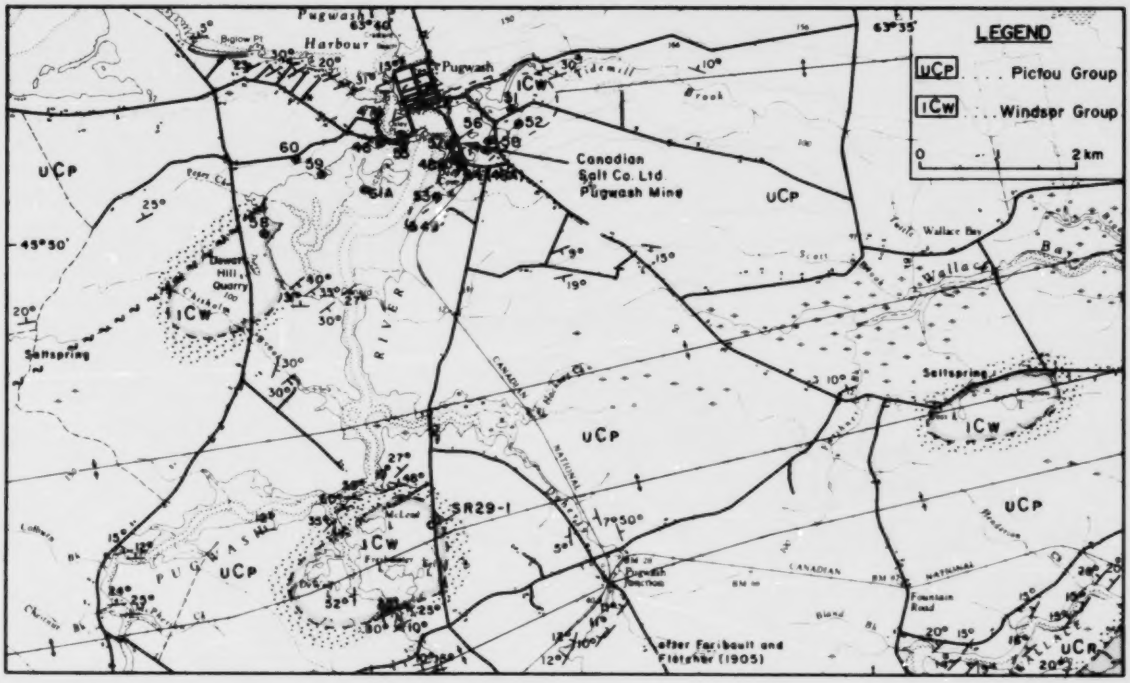

Figure 1. Geology and location map, Pugwash area

The Canadian Salt Company mine at Pugwash affords an opportunity to examine the internal structure, sedimentology and stratigraphy of a complex diapiric evaporite deposit. This deposit appears to be typical of diapiric anticlines developed within the Cumberland Basin and may be representative of discrete diapirs developed in deeper portions of the Maritimes Basin.

LOCAL GEOLOGY

Windsor Group strata occur in a northeast trending elongated ellipsoidal pattern at Pugwash in the Cumberland Basin (Fig. 1). Surface exposures consist of steeply dipping to overturned mudstone-sandstone with fossiliferous marine carbonate (B subzone; Bell, 1958) to the southwest of the Pugwash Mine. At this locality (Dewar Hill Quarry) Upper Carboniferous rocks rest with angular unconformity on the steeply dipping Windsor Group. The remainder of the area is predominantly submerged beneath Pugwash Harbour, however karst topography, diamond-drilling and underground mine workings indicate the rocks are dominantly deformed evaporites (salt and anhydrite). Although the stratigraphic and structural relationship of the evaporites to the strata at Dewar Hill is not clearly defined, the evaporites are interpreted to be older.

The geology of the Pugwash Salt Mine has been described by Evans (1965, 1967, 1972 and 1974). This work documents the internal structure, mode of deposition and stratigraphy of the deposit based on the workings available at

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

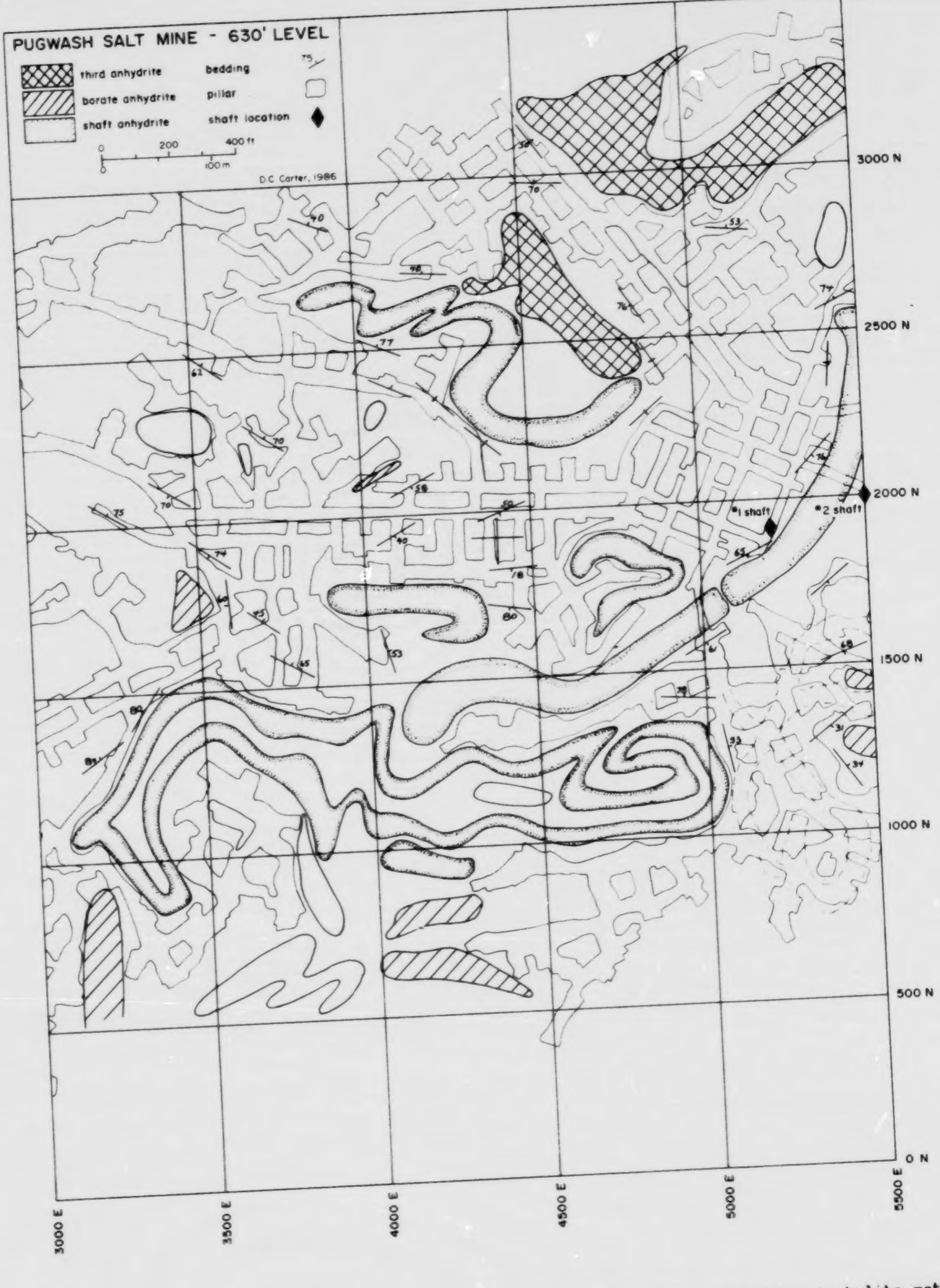

PUGWASH SALT MINE - 630' LEVEL
third anhydrite
borate anhydrite
shaft anhydrite
bedding
pillar
shaft location
0 200 400 ft
100 m
D.C. Carter, 1986
3500 N
3000 N
2500 N
2000 N
1500 N
1000 N
500 N
0 N
3000 E
3500 E
4000 E
4500 E
5000 E
5500 E
1 shaft
2 shaft

Figure 2. Pugwash salt mine, 630 level, mining plan showing anhydrite distribution in halite matrix

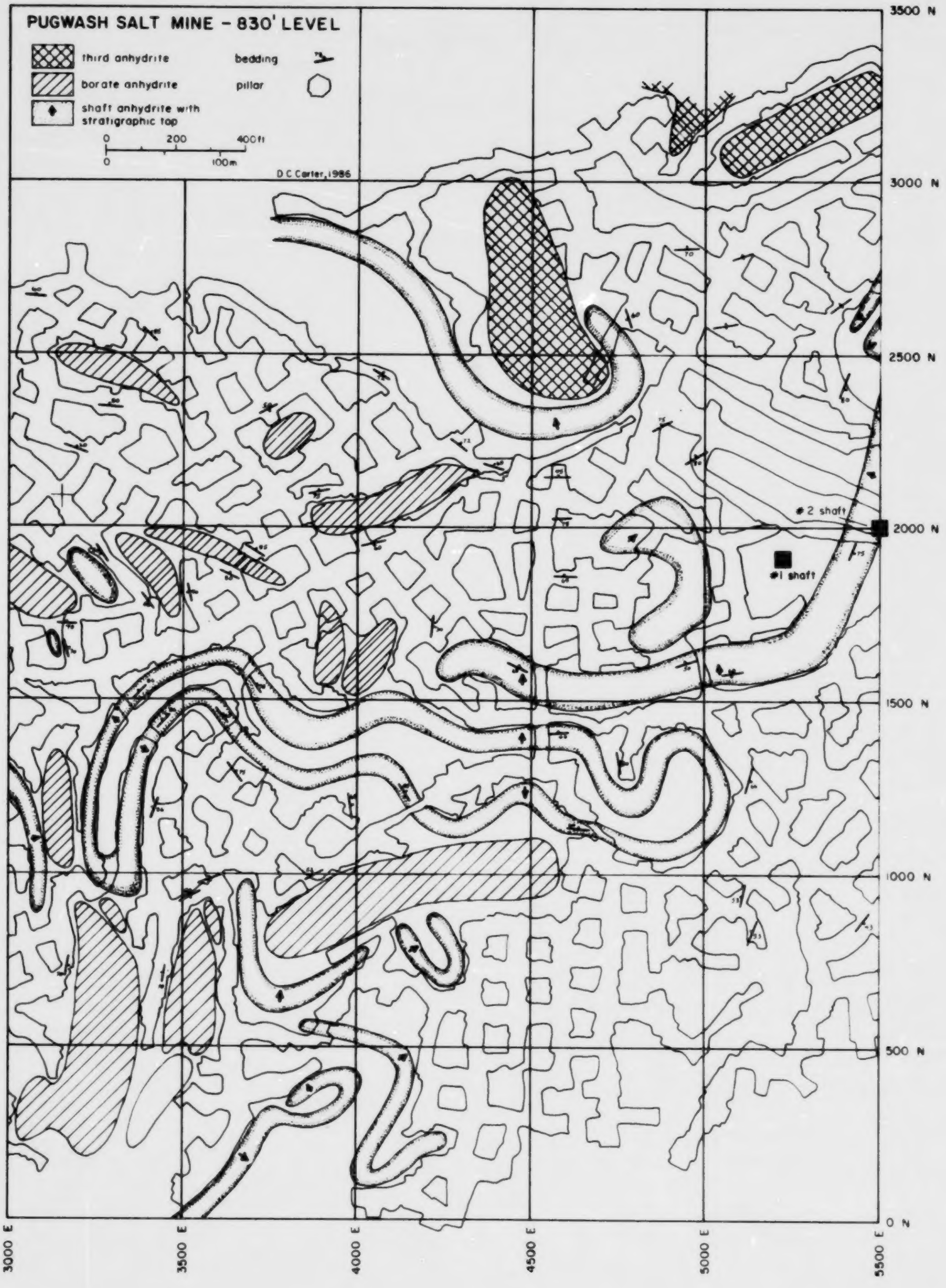
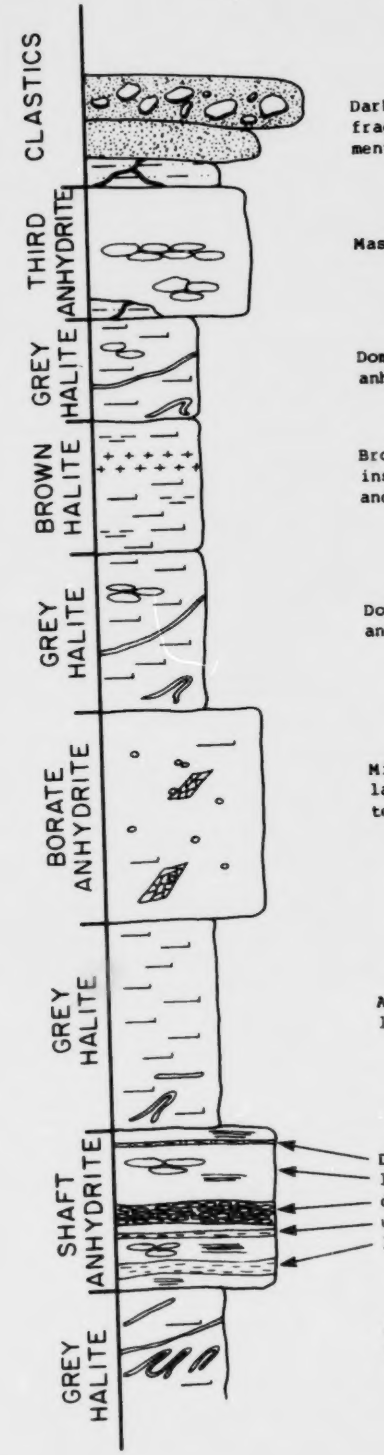

PUGWASH SALT MINE - 830' LEVEL
third anhydrite
borate anhydrite
shaft anhydrite with stratigraphic top
bedding
pillar
0
200
400ft
0
100m
D C Carter, 1986
#2 shaft
#1 shaft
3500 N
3000 N
2500 N
2000 N
1500 N
1000 N
500 N
0 N
3000 E
3500 E
4000 E
4500 E
5000 E
5500 E

Figure 3. Pugwash salt mine, 830 level, mining plan showing anhydrite distribution in halite matrix; note the location of the 3-dimensional block shown in Figure 5.


CLASTICS
THIRD ANHYDRITE
GREY HALITE
BROWN HALITE
GREY HALITE
BORATE ANHYDRITE
GREY HALITE
SHAFT ANHYDRITE
GREY HALITE

Dark greenish grey to black, oil stained; siltstones fractured by anhydrite filled veins; anhydrite fragments in basal conglomerate

Massive to nodular and stylolitic with minor sulphur

Dominantly anhydrite insolubles; planar and contorted anhydrite laminae and nodules

Brown, orange, grey to black tinted by clay insolubles and minor primary copper-red carnallite and white, yellow and orange sylvite

Dominantly anhydrite insolubles; planar and contorted anhydrite laminae and nodules

Minor small crystals of primary halite and medium to large vugs filled with secondary halite; minor minute to small found danburite nodules

Anhydrite insolubles; contorted anhydrite nodules and laminae, more abundant toward base.

Dolomitic, oil-bearing siltstone;
laminated to nodular anhydrite;
dolomitic siltstone with small anhydrite nodules;
upper greenish grey clay;
lower grey and pale orange clay

Abundant, highly contorted anhydrite laminae and nodules.

Figure 4. Pugwash salt deposit, stratigraphic column based on preliminary work; no scale implied.

that time (630 ft level). Additional work on the bromine geochemistry (Baar, 1966) and authigenic minerals (Aumento, 1964) was done on the same area. Work is currently in progress (Carter, 1985) on the sedimentology, stratigraphy and structure of the deposit incorporating data from the 830 and 730 ft levels and exploratory work for the 1000 ft level.

The evaporite sequence exposed in the Pugwash Mine consists of massive, nodular and stylolitic anhydrite and clear, white, reddish brown to black halite with minor occurrences of carnallite and sylvite. The anhydrite and halite occur both as thick beds and thinly interbedded intervals transitional to each other. The sequence has been extensively deformed and Evans (1972) concluded that the fold configuration and severity of deformation were similar to the structural configuration of diapirs, but suggested the Pugwash structure is intermediate between a true piercement diapir and a deformed anticline. The halite, and to a lesser extent, the anhydrite have deformed plastically. The halite shows extensive flowage characteristics including mylonite development. The anhydrite units in contrast were ruptured and rafted passively by halite flowage with resulting attenuation and elimination of parts of the sequence. This boundinage development (at scales ranging from centimetres to tens of metres) has left a complex series of steeply dipping anhydrite units interstratified with and isolated in a halite matrix (Fig. 2 and 3). Similar sequences have been noted by Richter-Bernberg (1980) as typical of emigration or thinning of the salt deposit and here are combined with a predominant structure of curtain folds having more or less vertical axes. This results in all imaginable figures and shapes within the deposit. Current work indicates that the Pugwash salt deposit represents a true piercement diapir and the present volume of salt may be a remnant of the original deposit.

Although the evaporite sequence is structurally complex, individual anhydrite units and ultimately the intervening halite units can be identified and correlated. Goodman (1985) suggested ten anhydrite units comprise the sequence, however, Evans (1972) and Carter (1985) identified two lithologically distinct anhydrites which can be correlated throughout the deposit. Current work indicates that there are three anhydrite units.

Figures 2 and 3 are partial plan maps of the 630 ft and 830 ft working levels, respectively, and show the distribution and identification of the anhydrite units. These anhydrite units can be correlated between working levels and may be used to plan future working levels.

The stratigraphic sequence exposed in the Pugwash Mine is shown in Figure 4. The bottom of the evaporite sequence is assumed to be the salt underlying the shaft anhydrite member. The upper part of the evaporite sequence exposed by mining is stratigraphically and structurally conformable with the clastics. The third (uppermost) anhydrite is sulphur-bearing and the overlying clastics are oil-stained. The nature and significance of these shows are being evaluated. Due to extensive deformation and flowage of the halite only estimates of the true thickness of the units, except the anhydrite, are possible. Work on the stratigraphy of the deposit is continuing. The stratigraphic should be considered a 'best fit' compilation of isolated data due to the disrupted nature of the deposit (Figs. 2 and 3).

Figure 5 is an interpretation of the three-dimensional form of anhydrite units within the Pugwash salt deposit (see Fig. 3 for location). The location of the 830 ft level - 1000 ft level decline which is currently under development and the proposed 1000 ft level horizontal drift in relation to the anhydrite are shown. This interpretation indicates that the 1000 ft level horizontal drift will probably intersect a considerable section of anhydrite. This block represents a very small portion of the Pugwash salt deposit (Fig. 3) and only one aspect of the documentation work currently in progress.

SUMMARY

The Canadian Salt Company mine at Pugwash, Nova Scotia affords a unique opportunity to examine an evaporite diapir which may prove to be representative of other deposit structures within the Cumberland Sub-basin and perhaps the Maritimes Basin.

Although the evaporite sequence is structurally complex, individual anhydrite units and ultimately the intervening halite units can be identified and correlated laterally and vertically. This continuing documentation work is expected to lead to a better understanding of the development of evaporite structures in general and a more comprehensive understanding of the Maritimes Basin, and to aid in future development in the Pugwash Mine.

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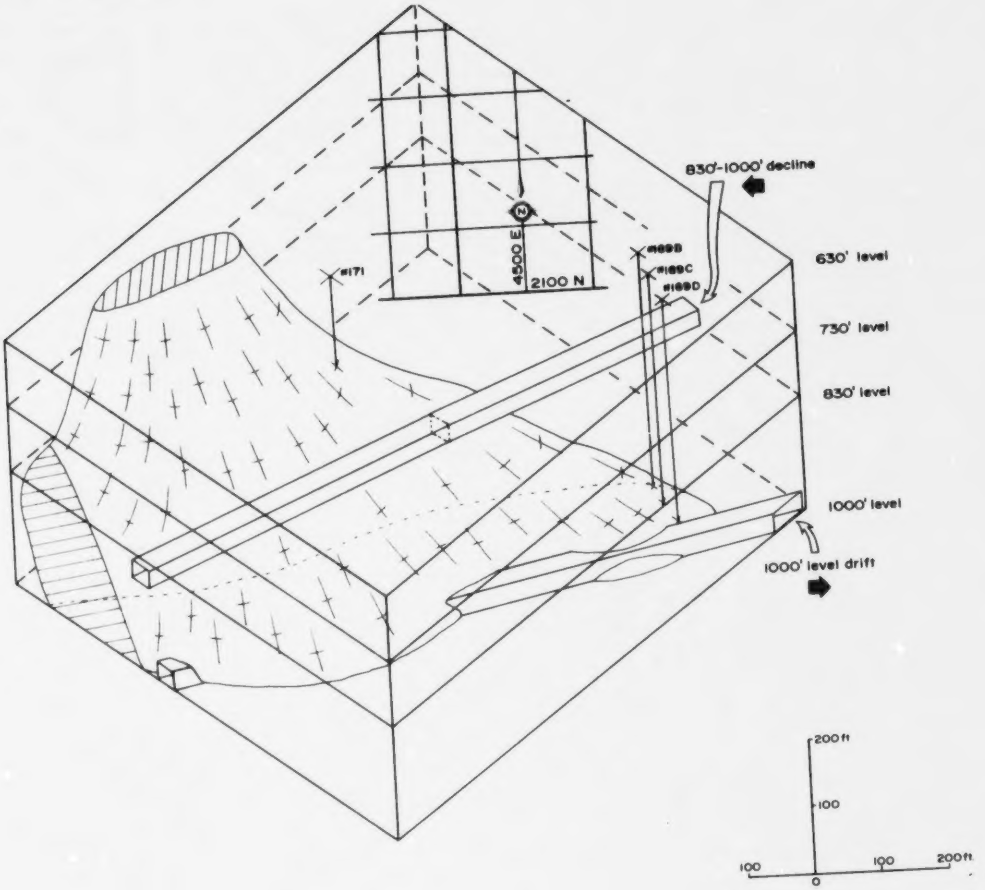
830'-1000' decline
630' level
730' level
830' level
1000' level
1000' level drift
#171
#169B
#169C
#169D
N
4500 E
2100 N
200 ft
100
100
0
100
200 ft

Figure 5. Pugwash salt deposit, three-dimensional block showing vertical distribution of anhydrite relative to proposed mine workings; see Figure 3 for location.

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METALLOTECTONIC MAP

J. D. Keppie

GENERAL BACKGROUND

Until the 1950s the relationship between mineral deposits and tectonic setting received very little attention because most deposits were considered to be related to intrusive magmatic processes, which were generally unrelated to the host rocks. Starting in 1948, Bilibin and other Russian geologists derived geotectonic groups of mineral deposit types related especially to intrusive rocks occurring at various geosynclinal stages (Tables 1-3; Bilibin, 1955; McCartney and Potter, 1962). This led to the production of metallogenic maps in many countries around the world.

Table 1. Plate tectonic terms and equivalent geosynclinal and Russian stages

PLATE TECTONIC STAGE	GEOSYNCLINAL STAGE	RUSSIAN GEO-SYNCLINAL STAGE AND METALLOGENY
Stable	Post-geosynclinal	Post-orogenic ?granodiorite (Cu, Mo, Au)
Transpression collision	Late orogenic molasse	Orogenic granite and pegmatite (Sn, W, Mo, Bi, F)
Pacific subduction	Early orogenic flysch	Early-late orogenic volcanism (Cu, Pb, Zn); Diorite-granodiorite (Au)
Atlantic spreading	Late generative shelf and ophiolite	Initial ophiolitic (Pt, Cr)
Rift	Early generative	Post-orogenic/ final carbonate (Pb, Zn, Ba)

(after Bilibin, 1955 and others)

With the advent of plate tectonics, there were attempts to relate mineralization to plate tectonics (e.g. porphyry Cu and Sn-W to subduction-related magmatic arcs, and stratiform massive sulphides to volcanic arcs (Kuroko-type) and mid-oceanic ridges (Cyprus-type)). While initial emphasis was upon the deposits in magmatic arcs and oceanic rise settings, other tectonic settings are now receiving increasing attention (e.g. intracontinental rifts and collisional magmatism (Mitchell and Garson, 1981)). This should lead to a new generation of metallogenic maps depicting the origin of mineral deposits in terms of their related plate tectonic setting.

The term "Metallotectonic Map" is proposed here to distinguish these maps from the earlier generation of metallogenic maps. First attempts in this direction were made by Chatterjee (1983) for Nova Scotia and government geologists in New South Wales, Australia. However this has largely been accomplished by superimposing the metallogenic data on a plate tectonic map or a modification thereof. No comprehensive tectonic grouping of mineral deposits, as accomplished by Bilibin (1955), has been produced in this manner. This will be attempted for the "Metallotectonic Map of Nova Scotia", in which the term "Metallotect" is used for the tectonic groups of mineral deposit. A "Metallotect" is defined as a genetically related group of ore elements which is cogenetic with a tectonic element. Tables 4a-d depict the type of data being compiled for the mineral deposits in Nova Scotia.

BASE MAP

The base for the metallotectonic map will be an updated version of the Tectonic Map of Nova Scotia (Keppie, 1981; 1982) modified to show new mapping and interpretations. The legend will be changed to include isotopic age data and plutonic rocks reclassified to show their tectonic setting. Rock units or tectonic elements anomalous with respect to specific metals or groups of metals will be shown with an overprint pattern. Potential mineralization domains derived from spatial geological, geophysical, geochemical and remote sensing parameters associated with metallotects will be outlined.

MINERAL OCCURRENCE SYMBOL

Two alternative methods of presentation are under consideration. In the first, the main symbol (Fig. 1) will be coloured according to its metallotect:

1. the outer part of the symbol will be coloured to show the percentage of different metals; a superimposed pattern will indicate whether the metal is a sulphide, silicate, native metal, oxide, sulphate, carbonate, halide, etc., and
2. the inner part of the symbol will be coloured according to the genetically related tectonic element with the appropriate abbreviation.

Surrounding symbols will show:

1. genetic factors: the source of the fluids and metals, the age of the deposit and the metal source age,

Table 2. Russian metallogenic associations and tectonic scheme based on geosynclinal theory

PHASE	DEFORMATION	STRATIGRAPHY	INTRUSIVE	DEPOSIT	NO.
Final	Weak faulting	Terrestrial sediments and flows			
		CA volcanism		Pb, Zn, Cu, F, Ba, Fe, (Hg, Sb)	
		Molasse	Porphyry diabase		F-2
			CA, A and ultra-mafic	Ba, Fe, Ag, Zn, Pb, Ni, Bi Cu, Co, Au, As, F	F-1
Late	Epeirogenic faulting	Continental CA volcanics		Hg, Sb, As (W)	L-6
			CA, and acid porphyry	Pb, Zn, Ag (As)	L-5
		Evaporites	Int. porph.	Al, Mo, Cu, Au	L-4
		Petroliferous rocks	CA	Pb, Zn, Sn, Ag, As, (W, Mo)	L-2
		Terrestrial and carbonate	Ca and porphyry	Mo, Au, Cu (Pb, Zn) As, W, Sb, Hg, Co	L-1
Middle	Uplift and folding	Erosion	Acid	W, Mo, Sn, Bi, F Li, Be, Ta, Nb	M-3
		Flysch	Int.	W, Mo, Au (As, Co) Sn, Fe	M-2
	Subsidence	Int. Voc.	Int. Porph.	Au (W, As, Sb, Mo)	M-1
Early	Uplift	Erosion CA volcanism		Au, Ag	E-5
			CA	Cu, Fe, Ag, Pb,	E-4
	Local folding	Rise and mafic volcanics	Na-porph.	Zn, Au, Ba	E-3
			Ca-mafic	Fe, Cu (Co, As)	E-2
	Subsidence		A mafic-int.	Au, As, W, Cu, Mo	E-1
Initial	Local	Mafic flows and deep-sea	Ultramafic-mafic	Ti, Fe, Cu, Ni, Cu	I-2
			Ultramafic-int.	Pt, Cr, Fe, Ti, Ni asbestos	I-1

(modified from McCartney and Potter, 1972, after Bilibin and others 1955, 1965)

2. location controlling factors: host rock lithology, structure and metamorphism, and
3. exploration indicators: geochemical and geophysical anomalies.

An alternative method of representing the mineral occurrence data is in the form of a series of transparent overlays with one for each group of associated elements (e.g. Cu-Pb-Zn,

Table 3. Metallotects and their relationship to plate tectonic stages and elements

	METALLOTECT		
TECTONIC STAGE	TECTONIC ELEMENT	METAL ASSOCIATION	GENESIS
STABLE	Epicontinental basin (eb)	Stratabound (Fe-Mn-oil-gas)	Supergene epigenetic
	Intracontinental basin (ic)	Unconformity vein-type (U)	Supergene diagenetic epigenetic hydrothermal metamorphic
		Quartz-pebble conglomerate (U-Au)	Detrital epigenetic
	Platform (p)	-	
TRANS-PRESSION	Collision plutons (cp) in foreland and retroarc thrust belts	"S-type" leuco- and peraluminous and "I-type" granite (Sn-W-U-F-Mo-Au-Ag-Zn-Pb-Cu)	Meteoric-magmatic
		Pegmatitic rare metal, gemstones (Nb-Ta-B-Be-Li-Sb-Hg)	Magmatic metasomatic
		Vein-type arsenide (Ag-Ni-Co)	Magmatic hydrothermal
	Collision anorthosite (ca)	Massive (Fe-Ti)	Magmatic
	Suture Zone (sz)	Melange (Jadeite-Nephrite)	Metamorphic
	Collision structure (cs)	Fold-fault (Au-Zn-Mn)	Metamorphic
	Foreland basin (fb)	Stratabound sandstone (U-Cu-V-Au)	Detrital diagenetic epigenetic
		Stratabound (Pb-Zn-Cu-Ag-Ba)	Meteoric-epigenetic
		Evaporites, coal (E-C)	Seawater organic
	Hinterland basin (hb)	(as in fb)	
	Intramontane basin (imb)	Stratabound sandstone (U-Cu)	Meteoric epigenetic
		Stratabound (Pb-Zn-Cu-Ag-Ba)	Meteoric epigenetic
		Evaporites, coal (E-C-Ba)	Seawater organic
	Volcanic rift (vr)	Alkalic-tholeiitic volcanism (U-Fe-Th-REE-Sr-Ba-verm)	Magmatic epigenetic
PACIFIC	Retroarc compressive basin (racb)	Evaporites-coal (E-C)	Seawater organic
		Alluvial (Au-Sn)	Detrital
	Retroarc extensional basin (raeb)	Veins associated with bimodal volcanism (Au-Hg-F-Sb)	Meteoric-magmatic
	Back-arc and inter-arc basin (bab;iab)	Black shale (P)	Seawater
	Back-arc basin oceanic crust (baboc)	Pillow basalt sulphides (Cu-Fe-Zn)	Seawater magmatic
	Back-arc basin upper mantle (babum)	Ultramafics-basalt podiform (Cr)	Magmatic
	Back-arc basin seamount (babs)	?Besshi-type stratiform sulphide (Cu-Zn)	Magmatic
	Volcanic arc (va)	Andesitic-dacitic volcanics (Hg-Au-Te)	Magmatic metamorphic
		Mafic volcanics (Sb-W-Hg)	Seawater-magmatic
		Felsic volcanics (Fe-apatite)	Magmatic seawater
	Volcanic arc rift (var)	Kuroko-type (Zn-Pb-Cu-Au-Ag)	Seawater magmatic
	Magmatic arc (ma)	"I-type" porphyry (Cu-Au) (Cu-Mo) (Au)	Magmatic-meteoric
		"S-type" granite (Sn-W)	Magmatic-meteoric
	Forearc basin (fab)	Fluviatile placer (Au)	Detrital
		Deltaic Coal (fabC)	Organic
	Forearc (fa)	Granite (Sn-W-B)	Magmatic
		Flysch-quartz-carbonate	Meteoric connate
		(Hg-Sb-W)	metamorphic
	Trench complex (tc)	Quartz vein (Au)	Connate metamorphic

Table 3. Continued

	METALLOTECT		
TECTONIC STAGE	TECTONIC ELEMENT	METAL ASSOCIATION	GENESIS
RIFT	Within plate pluton (wpp)	Carbonatites (Cu-U-Ree-Sr-Apatite-Vermiculite-Magnetite-Pyrochlore)	Magmatic
		Kimberlites (C)	Magmatic
		Alkaline complexes (Sn-Nb-Apat)	Magmatic meteoric
		Basic-ultrabasic (Cr-Ni-Pt-Cu)	Magmatic
		Granite porphyry (Mo-Cu-Ag-Co-Ni)	Magmatic
		Veins in faults (F)	Meteoric connate magmatic
		Veins in shale (Pb-Zn)	Magmatic connate
	Volcanic rift (vr)	Basanite (Al-gemstones)	Magmatic
	Rift valley (rv)	Stratabound sandstone (U)	Meteoric-epigenetic
		Evaporites (E)	Seawater meteoric
		Stratabound Sullivan-type (Ag-Pb-Zn)	Meteoric-epigenetic
		Stratabound (Cu)	Meteoric-epigenetic
ATLANTIC	Oceanic crust layer 1 (oc1)	Pelagic sediments and nodules (Mn-Ni-Co-Cu-Au-Ag-Zn-Ba-Fe)	Seawater magmatic ?meteoric ?connate
	Oceanic crust layer 2 (oc2)	Ocean ridge basalts Cyprus-type (Cu-Fe-Zn)	Seawater magmatic
	Oceanic crust layer 3 (oc3)	Cumulate gabbro (Cu-Ti)	Meteoric magmatic
ATLANTIC (cont'd)	Upper mantle (um)	Podiform (Cr)	Magmatic
		Ultramafic (Ni-Pt-Au-Fe-Ti-asbestos-talc-Mg)	Magmatic
	Oceanic transform fault (ot)	Cyprus-type (Cu-Fe-Zn) (Ba)	Seawater magmatic
	Oceanic seamount (os)	?Besshi-type stratiform sulphide (Cu-Zn)	Magmatic
	Microcontinental submarine platform (mcsp)		
	Microcontinental shelf (mcs)	(same as cs)	
	Continental rise and slope (cr)	Turbidite (Oil-Gas)	Organic
	Continental shelf (cs)	Placers (Ti-Zr)	Detrital
		Evaporites (E)	Seawater
		Phosphorites (P)	Seawater organic
		Carbonate-hosted (Pb-Zn) (Ba-F)	Meteoric connate
		Banded iron formation and chert (Fe)	Seawater organic
		Minette-type ironstones (Fe)	Seawater
		Pelagic shales (Ag-Ni, Cr-V-Mo-Cu-Pb-Zn-U)	Seawater

(modified from Mitchell and Garson, 1981)

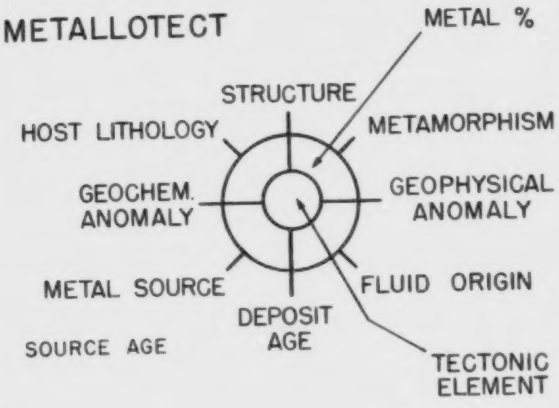

Figure 1. Mineral occurrence symbol

Sn-W-U, Au, etc). In this case, the outer part of the coloured symbol and surrounding symbols will be on the overlays. This method has the advantage of simplifying the reading of the map.

APPLICATION

The depiction of factors controlling the present location of known mineral deposits and occurrences together with geophysical and geochemical anomalies should provide a powerful exploration tool for allowing extrapolation into areas possessing similar geological factors and anomalies but as yet undiscovered mineral occurrences. Knowledge of the genesis of individual deposits should allow the generation of predictive models for the location of environments where deposits have yet to be discovered. For example, several tectonic elements are present in Nova Scotia, but the associated metallotect is at present unknown. Also, tectonic elements or rock units which are

Table 4a. Mineral occurrences and metallogenic

LOCATION					SIZE	DESCRIPTION				MINERALOGY		CHEMISTRY			NAME
OCC #	GM #	MM #	LATITUDE	LONGITUDE	PRODUCTION	FORM	ORE CHARACT	HOST ROCK	ROCK UNIT	PRIM MIN	ASSOCIATED MINERALS	PRIM COMM	ASSOCIATED COMMODITY	ASSAY	

Table 4b. Tectonic

GEOLOGICAL CHARACTISTICS																
HOST ROCK		VOLCANIC/PLUTONIC						STRUCTURE		METAMORPHISM		INTERPRETATION				NAME
UNIT	AGE	NATURE	TECTONIC	AGE	Rb/Sr(i)	U/Pb up	SOURCE	NATURE	AGE	GRADE	AGE	PROVINCE	STAGE	ELEMENT	METALLOTECT	

Table 4c. Type mineral deposit data (fluid inclusions and isotopes)

FLUID				ISOTOPES						AGE					NAME
TEMPERATURE	pH	SALINITY		$\zeta^{18}O$	$\zeta^{34}S$	$\frac{^{208}Pb}{^{204}Pb}$	$\frac{^{207}Pb}{^{204}Pb}$	$\frac{^{206}Pb}{^{204}PB}$	Other	K/Ar	$^{40}Ar/^{39}Ar$	Rb/Sr	U/Pb		
		NaCl	KCl												

Table 4d. Exploration indicators and targets

GEOPHYSICAL CHARACTERISTICS						GEOCHEMICAL CHARACTERISTICS						NAME
MAGNETIC ANOMALY	GRAVITY ANOMALY	RADIOMETRIC			EM Anomaly	MEDIUM	TYPE OF ANOMALY	REGIONAL ANOMALY	DISPERSON (km)	LOCAL ANOMALY		
		eK	eU	eTh								

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anomalous with respect to certain metals have potential for undiscovered deposits.

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REGIONAL GEOCHEMICAL STUDIES IN NOVA SCOTIA

P. J. Rogers, R. F. Mills and P. A. Lombard

THE MEGUMA ZONE

METHODS FOR LAKE SEDIMENT SURVEYS

The first regional centre-lake bottom sediment survey of the Meguma Zone (MZ) took place in 1977 and 1978 during which about 4000 samples were collected using gravity corers mounted on float-equipped helicopters (Bingley and Richardson, 1978; Richardson and Bingley, 1980). A sampling density of approximately 1 per 5 km^2 was employed, covering most of the lakes in the MZ (Garrett et al., 1982). In 1985, approximately 2950 of these original samples were reanalyzed for Cu-Pb-Zn-Ag-F-Li-Rb-Nb-Ti-Sn-Zr-Th-Sb-As-W-Au, when sufficient sample permitted (Rogers et al., 1985). Table 1 lists the basic analytical methods for the 16 elements reanalysed.

Table 1. Summary of analytical methods

GROUP	ELEMENTS	METHOD	DETECTION LIMIT
1	Cu,Pb,Zn, Ag,Li	atomic absorption spectroscopy	1 ppm except Ag 0.1 ppm
2	F	specific ion electrode	20 ppm
3	Nb,Rb,Sn, Zr,Ti	X-ray fluorescence	1 ppm except Ti 10 ppm
4	Th,Sb,As, W,Au	instrumental neutron activation	As,W 1 ppm Th 0.5 ppm Sb 0.2 ppm Au 5 ppb

Notes:

a. Groups 1 and 2 used a total dissolution technique of hydrofluoric, perchloric and nitric acids.

b. Due to the effects of the high organic content of lake sediments the instrumental neutron activation results for Au have a higher detection limit of 5 ppb compared to the usual 1 ppb for the method.

c. All analyses performed at Bondar-Clegg and Company, Ottawa, Ontario.

Geological Survey of Canada quality control procedures, as outlined by Garrett et al., (1980), were followed for the total dataset of 3400 samples (including controls). The URPSTAT statistical program was applied to the data (Garrett, 1977) to produce basic statistics (Table 2) and a tabular list of anomalous values. In the data analysis each sample was assigned a ratings score, based on its elemental value, to characterize the multielement nature of the anomalies for each of 16 elements as follows:

> 90th percentile < 95th percentile: Score = 1
> 95th percentile < 98th percentile: Score = 2
> 98th percentile < 99th percentile: Score = 3
> 99th percentile: Score = 4

A multiple rating (Table 3) was obtained by summing each individual element score. The total score was then assigned to each sample. Lake catchment basin lithology was also recorded for each site as part of the original survey and this was used to subdivide the dataset into principal lithologies. Using URPSTAT, basic statistics were also calculated for each of four subsets based on these principal lithologies. All sample locations were digitized and merged with the analytical data, multiple rating scores and catchment lithology datasets for computer plotting.

Single element colour Applicon plots at the 1:500 000 scale were produced from the merged dataset for all elements. The principal lithologies of the MZ were each assigned a different symbol, its size proportional to the magnitude of the multiple score or rating, and the total scores were then plotted at the same scale as the colour plots.

RESULTS

REGIONAL SINGLE ELEMENT PLOTS

The Applicon colour computer plots for the MZ are reproduced in Figures 1a and 1b. The regional Sn plot shows elevated concentrations up to 33 ppm over East Kemptville and up to 9 ppm over the New Ross - Millet Brook area. These elevated concentrations of elements strongly relate to the South Mountain Batholith (SMB) and thus confirm the known and expected granite related metallogeny in these areas (Chatterjee, 1983). The W plot outlines high values of up to 12 ppm around known deposits but, unlike the Sn plot, shows groups of distinct elevated concentrations in the exocontact zones of the SMB and the Musquodoboit Batholith (MB). A significant W anomaly of 10 ppm is located southwest of Halifax over the Mn-rich sediments of the transition zone between the Halifax and Goldenville Formations of the Meguma Group (O'Brien, 1986). This zone is located at the same stratigraphic horizon as the Eastville-type polymetallic deposit. The regional Au distribution plot outlines the known quartz vein deposits within the MZ, but it also indicates other anomalous areas over the SMB granitic rocks. This strongly suggests new

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*Funded by Geological Survey of Canada and Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

Table 2. Summary statistics of total dataset

ELEMENT	UNIT	ARITHMETIC MEAN	STANDARD DEVIATION	CV%	MINIMUM	MAXIMUM	NUMBER ANALYSES
Cu	ppm	12.6	8.3	66.3	1.0	94.0	2947
Pb	ppm	14.8	12.8	86.4	1.0	327.0	2947
Zn	ppm	58.0	47.1	81.2	1.0	510.0	2947
Ag	ppm	0.2	0.5	264.1	0.1	22.6	2947
F	ppm	119.0	78.6	66.1	20.0	990.0	2947
Li	ppm	8.7	8.6	98.4	1.0	78.0	2947
Nb	ppm	2.5	3.0	119.3	1.0	74.0	2920
Rb	ppm	37.5	31.1	83.1	1.0	521.0	2914
Sn	ppm	2.3	2.1	92.8	1.0	36.0	2933
Zr	ppm	86.8	66.9	77.1	1.0	565.0	2914
Ti	%	0.2	1.3	573.5	0.0	69.0	2914
Au	ppm	6.3	25.8	413.1	5.0	853.0	2886
Sb	ppm	0.3	0.3	96.1	0.2	10.2	2936
As	ppm	12.0	38.2	318.4	1.0	999.9	2936
Th	ppm	3.4	2.2	64.8	0.5	23.1	2936
W	ppm	1.5	8.1	548.4	1.0	434.0	2935

potential targets for Au exploration in granitic terrains. Most lakes overlying granitic rocks have enhanced Au background levels of up to 8 ppb when compared to lakes with 4 ppb background developed on the Meguma Group lithologies. The Ag plot reveals a distinct domain in southwestern Nova Scotia closely related to the SMB. There are also several northwesterly trending anomalous areas for Ag in southern Nova Scotia. The Ag plot also reveals some of the known specialized granites in the MZ, such as the Poptat Lake body, Digby County (Chatterjee, 1983).

MULTIELEMENT PLOTS

The multiple rating score, obtained by summing each element score, is used to plot a multielement map for all 16 elements from the MZ (Fig. 2). The multielement plots highlight the known overall MZ metallogenesis of Chatterjee (1983) with distinct domains outlined by high concentrations of anomalies such as over the South Mountain Batholith. The multielement rating scores approach also allows consideration of areas which are weakly anomalous in several elements and are not prominently outlined by the single element plots. The Little Dover area and

Table 3. Example of a multielement rating

SAMPLE LITHOLOGY	Cu Pb Zn ± Ag	F Li Nb Rb ± Sn	Sb As Au W	Th Zr Ti	SCORE
21A09 771017 GRANITE ■		● ● + ★ ✱		✱ ✱ ✱	19
11E02 771175 QUARTZITE △	✱ ✱	★ ★ ●	★ ★ ★ ★	✱	33
11D16 771031 SLATE ○	★ ✱ +	+ ✱ ✱	★	+ ✱ ✱	21

LEGEND

+ >90TH <95TH Percentile Score 1

✱ >95TH <98TH Percentile Score 2

● >98TH <99TH Percentile Score 3

★ >99TH Percentile Score 4

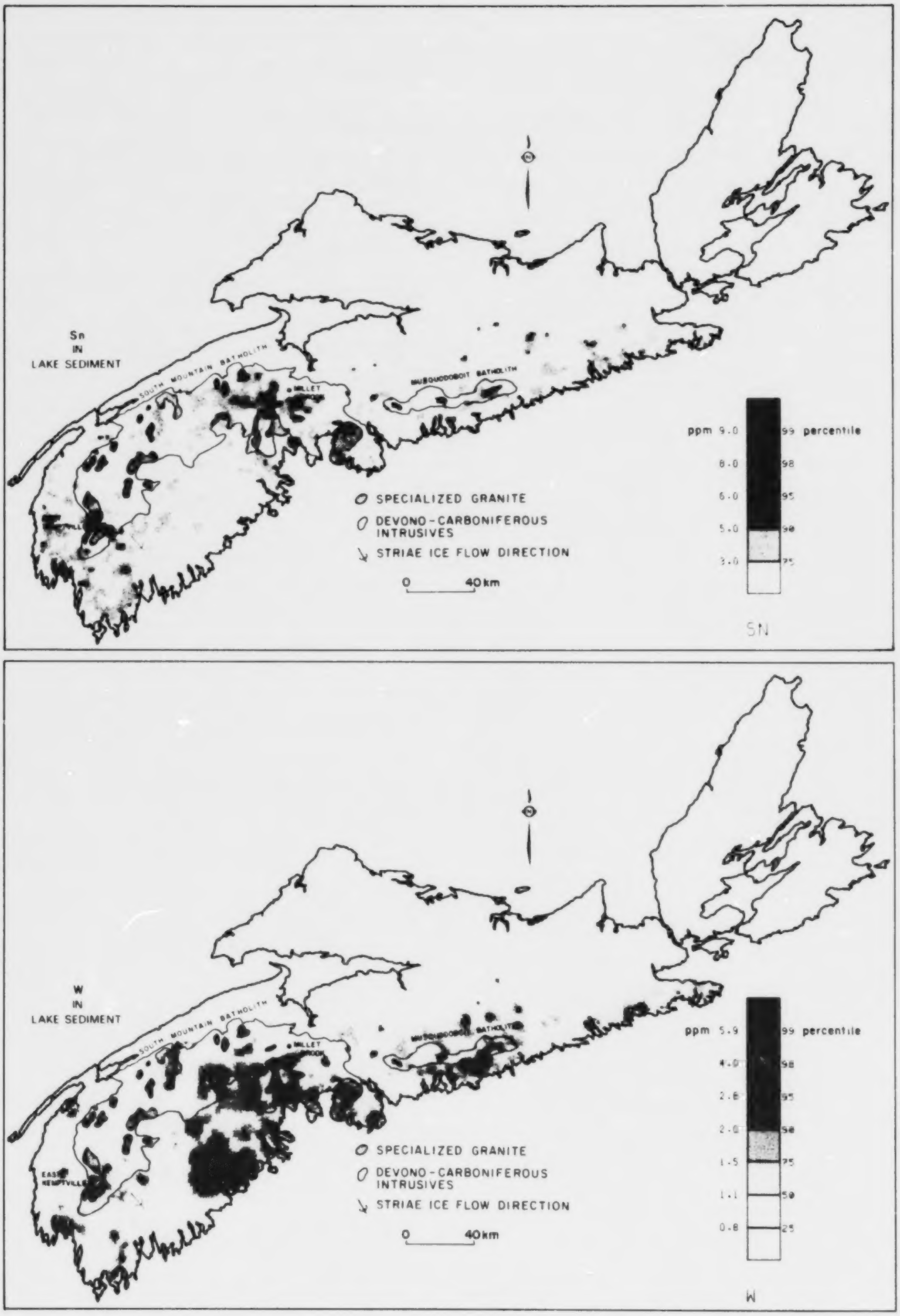

Sn
IN
LAKE SEDIMENT
SOUTH MOUNTAIN BATHOLITH
MILLET
MUSQUODOBOIT BATHOLITH
SPECIALIZED GRANITE
DEVONO-CARBONIFEROUS INTRUSIVES
STRIAE ICE FLOW DIRECTION
0 40km
ppm 9.0 99 percentile
8.0 98
6.0 95
5.0 90
3.0 75
SN
W
IN
LAKE SEDIMENT
SOUTH MOUNTAIN BATHOLITH
MILLET
MUSQUODOBOIT BATHOLITH
EAST KEMPTVILLE
SPECIALIZED GRANITE
DEVONO-CARBONIFEROUS INTRUSIVES
STRIAE ICE FLOW DIRECTION
0 40km
ppm 5.9 99 percentile
4.0 98
2.8 95
2.0 90
1.5 75
1.1 50
0.8 25
W

Figure 1a. Regional single element computer plots for Sn and W taken from Applicon colour originals

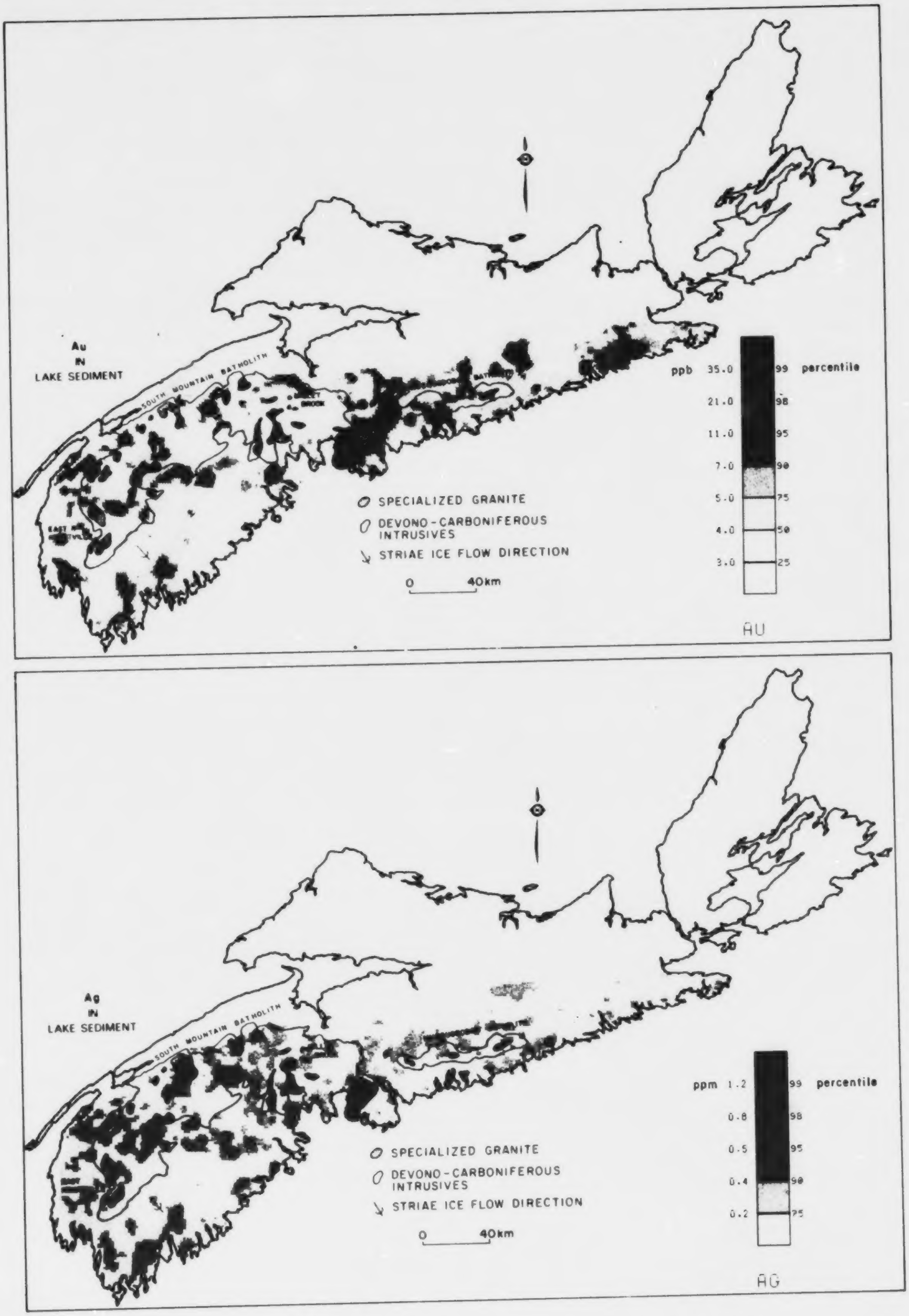

Au
IN
LAKE SEDIMENT
SOUTH MOUNTAIN BATHOLITH
SPECIALIZED GRANITE
DEVONO-CARBONIFEROUS INTRUSIVES
STRIAE ICE FLOW DIRECTION
0 40km
ppb
35.0
21.0
11.0
7.0
5.0
4.0
3.0
99
98
95
90
75
50
25
percentile
AU
Ag
IN
LAKE SEDIMENT
SOUTH MOUNTAIN BATHOLITH
SPECIALIZED GRANITE
DEVONO-CARBONIFEROUS INTRUSIVES
STRIAE ICE FLOW DIRECTION
0 40km
ppm
1.2
0.8
0.5
0.4
0.2
99
98
95
90
75
percentile
AG

Figure 1b. Regional single element computer plots for Au and Ag taken from Applicon colour originals

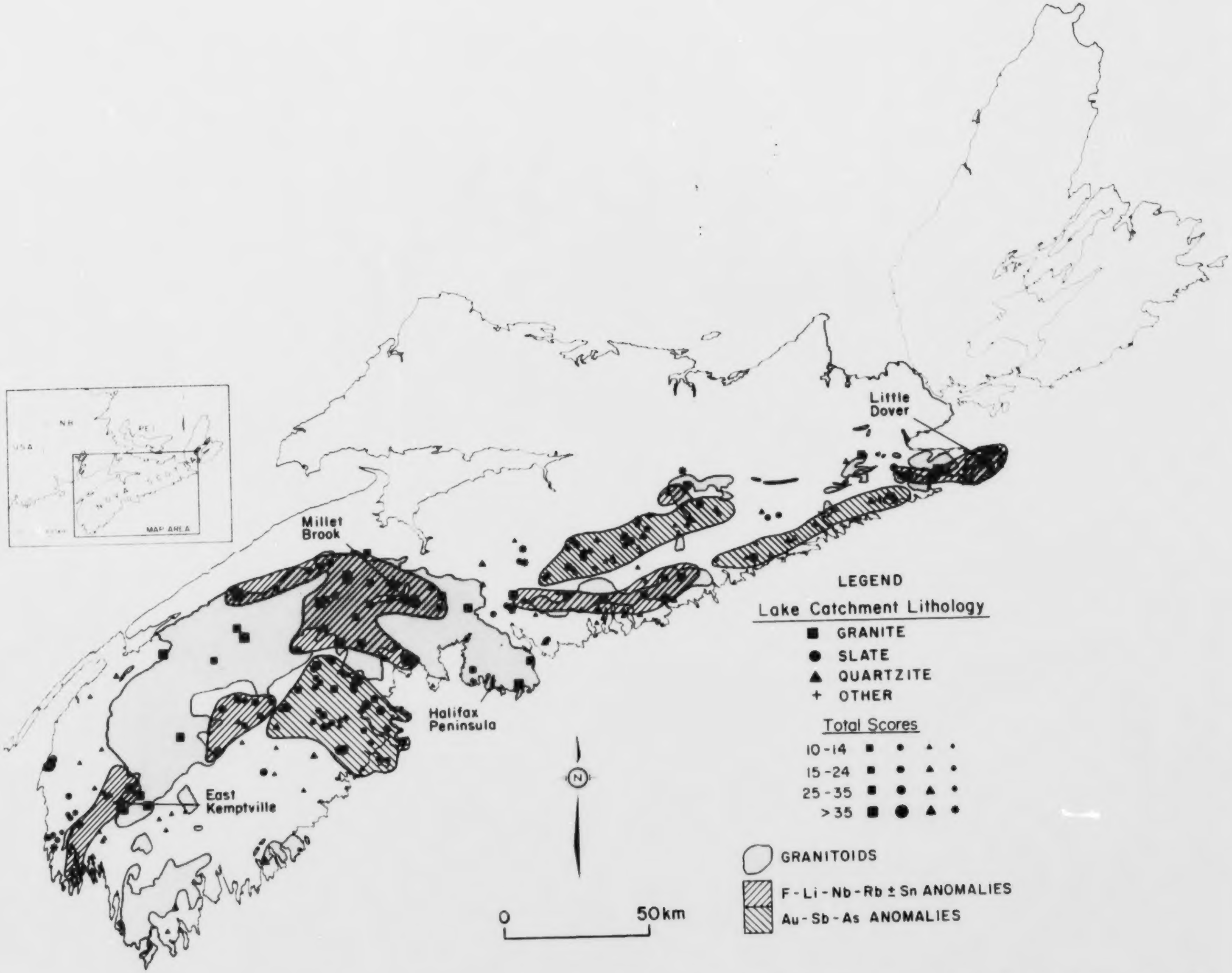

Little Dover
Millet Brook
Halifax Peninsula
East Kemptville
NB
PEI
USA
NOVA SCOTIA
MAP AREA
N
0
50km
LEGEND
Lake Catchment Lithology
■ GRANITE
● SLATE
▲ QUARTZITE
+ OTHER
Total Scores
10-14
15-24
25-35
>35
GRANITOIDS
F-Li-Nb-Rb ± Sn ANOMALIES
Au-Sb-As ANOMALIES

Figure 2. Ratings plot and multielement associations plot for the Meguma Zone, showing the distribution of anomalous areas for F-Li-Nb-Rb + Sn and Au-Sb-As for the principal lithologies, Meguma Zone, Nova Scotia.

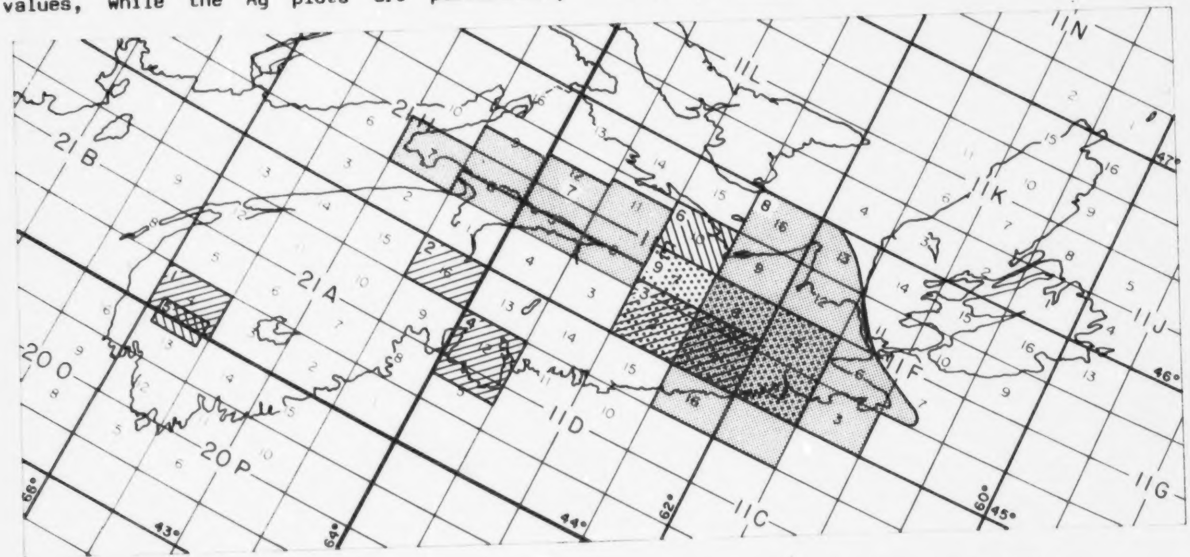
the Halifax Peninsula (Fig. 2) have varied multi-element signature. These areas are not highly anomalous for any one element but have high rating scores when all elements are combined. These areas may contain buried potential mineralization which is not directly exposed. As such, the multielement ratings score approach is one way to detect buried or blind ore bodies where they are subtly expressed, perhaps in the form of leakage or weak anomalies.

A number of important associations of occurring high rating scores are noted throughout the dataset: Cu-Pb-Zn+Ag, F-Li-Nb-Rb+Sn, Zr-Ti-Th and Sb-As-Au+W. The regional plot of two of these associations defines geochemically active areas within the MZ as groupings of high ratings (Fig. 2). The distinctive anomalous areas of lithophile or granophile elemental groupings of F-Li-Nb-Rb+Sn underscores the importance of the SMB as a metal generator. The Sb-As-Au siderophile-chalchophile association is enriched over MG sediments largely in the exocontact areas of the granitoid bodies.

DISCUSSION

The regional single element plots for Sn, W, Au and Ag in the MZ confirm known metallogeny, especially the role of the SMB and MB as the main bedrock hosts for Sn and W mineralization (Figs. 1a, b). Known Au deposits are detected in the Meguma Group sediments by anomalous Au values, while the Ag plots are particularly useful in detecting specialized granite areas within MZ batholiths. There are, however, a few surprises which challenge previously held exploration models for the MZ. The reanalysis of the lake sediments indicates that the granitoid rocks of the SMB have high exploration potential for Au and Ag. The specialized bodies within the host SMB are also characterised by high Li, F and Rb. Most previous exploration attention for Sn-W has been focused on SMB granitoids but the regional plots now indicate anomalous W areas in the exo- and endocontact zones within MG metasediments. The Goldenville Formation - Halifax Formation transition zone of the MG underlies an area of anomalous W and Sb values.

The consideration of multielement ratings (Fig. 2) for the dataset enables definition of distinct areas of high geochemical activity for all 16 elements. Appreciation of areas such as Little Dover, with a number of weak anomalies for individual elements, is enhanced. The ratings approach is one method to detect more subtly expressed anomalies due to buried or masked sources. It is also useful to identify the principal associations in the dataset (Fig. 2). In the MZ, F-Li-Nb-Rb+Sn and Sb-As-Au+W are the dominant associations. Most lithophile or granophile associations are located in areas overlying granitoids and siderophile-chalcophile associations overlying metasediments. Their boundaries closely follow the bedrock metallogenic domains of Chatterjee (1983) indicating that the lake sediments geochemistry closely resembles that of the underlying strata.



▨ Regional lake sediments - deposit studies
1. East Kemptville Sn - W
2. Millet Brook U
3. Liscomb Complex Au-Sb-As-Ni-Co
4. Halifax Peninsula Au - W

▧ Follow up studies - detailed sampling of tills, soils and streams
5. Rushmere Lake
6. Pictou

░ *Data Integration Projects
7. Cobequid Highlands
8. Eastern Nova Scotia

░ *Biogeochemistry
9. Liscomb

* Joint project with G.S.C.

0 100 km

Figure 3. Geochemical activity areas during 1986-1987

The lake sediments at East Kemptville have very similar element associations compared to those of the bedrock lithogeochemistry (Rogers and Garrett, in press). The grouping of principal associations enables anomalous areas to be identified as having high exploration potential. The use of these geochemical windows of grouped associations, where used in conjunction with single element values, is a powerful tool for defining areas for follow-up studies in mature mining districts such as Nova Scotia.

CURRENT GEOCHEMICAL ACTIVITY

The 1985 reanalysis of the regional lake sediment dataset is used to model the response of known deposit types at East Kemptville, Millet Brook, Liscomb Complex and on the Halifax Peninsula (Fig. 3). Detailed follow-up studies are in progress at Rushmere Lake for Sn-W-Au and Pictou for Pb-Zn-Ag. Additional joint projects are in progress with the Geological Survey of Canada for biogeochemistry (Liscomb) and data intergration in the Cobequid Highlands (Bonham-Carter et al., in press and Rogers et al., 1986) and the Eastern Shore study areas.

CONCLUSIONS

In southern Nova Scotia a major new exploration application for regional lake sediment surveys is described in the search for Li-Rb-Nb-F-Sn and Au-Sb-As-W mineralization. Regional lake sediment surveys will outline areas of grouped geochemical associations which reflect the distinct metallogenic character of the underlying strata and indicate new exploration targets for detailed follow-up work. Previously unsuspected precious metal potential is indicated for the granitoid rocks of the South Mountain Batholith. The important role of shear zones within the Meguma Zone as loci for Au and other mineralization has also been identified (Giles, 1985).

A regional centre-bottom lake sediment survey (using a 1 per 5 km^2 sample spacing and including Sn and W amongst the elements analysed) will detect the dispersion into lakes from the East Kemptville deposit (Rogers and Garnett, in press). Sampling of all lakes would have provided a better resolution of all potential mineralization available in the MZ.

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1986 REGIONAL GEOCHEMICAL STREAM SEDIMENT SURVEY

R. F. Mills, P. J. Rogers and P. A. Lombard

INTRODUCTION

In 1986 the Nova Scotia Department of Mines and Energy (NSDME) began a two year regional geochemical survey as part of the Nova Scotia - Canada Mineral Development Agreement (Fig. 1.) to sample the northern half of the Province (north of the Chedabucto Fault). The survey consists of a sampling program of stream sediments for heavy minerals and surface water samples. Sample density varies, but averages approximately 1 sample per 10 km^2.

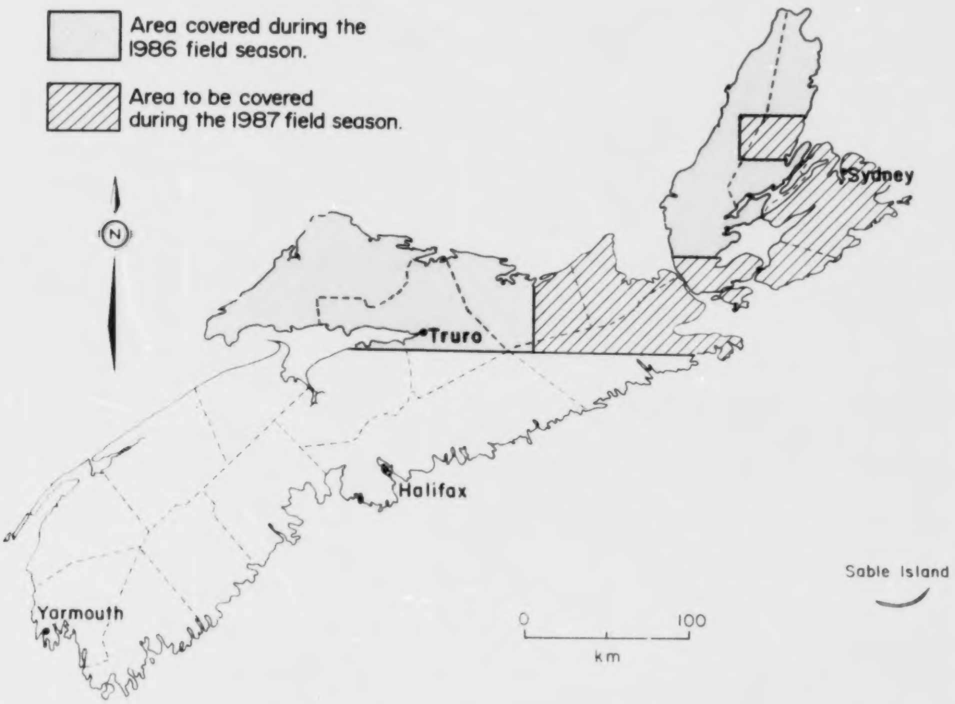
Area covered during the 1986 field season.
Area to be covered during the 1987 field season.
N
Sydney
Truro
Halifax
Yarmouth
Sable Island
0
100
km

Figure 1. Fieldwork coverage of the 1986-87 regional geochemical stream sediment survey

The survey will be integrated with previous geochemical surveys to provide information for the Nova Scotia Geochemical Atlas Project. Statistical problems are anticipated when merging the data with other types of surveys such as the lake sediment survey done within the Meguma Zone of the southern half of the Province (Bingley and Richardson, 1978). Various methods of data analysis have been applied to this problem of integrating statistics from mixed surveys, such as nonparametric tests (Rogers et al., 1984) and catchment basin analysis (Bonham - Carter et al., 1986). Other atlas-related information will be derived from till surveys, lithogeochemistry and NSDME assessment reports.

FIELD METHODOLOGY

Reliable field methodologies must be implemented for any geochemical survey. The geochemistry section of NSDME has experienced several pilot projects (Rogers and MacDonald, 1984). The basic field sample is a large -18 mesh stream sediment sample sieved on site. To avoid contamination problems the field equipment consists of nylon mesh (nytex) screening supported by a wooden housing and held in place by nylon bolts. The sample and all water used in the sieving are collected in a plastic pan. The +18 mesh material are visually inspected and then discarded. Due to the large size the sample may be split more than once and re-analyzed in the future.

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*Funded by Geological Survey of Canada and Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

Several workers, most notably Boyle (1979) have documented the possibility of fine gold loss by surface water tension. The field sampling procedure attempts to avoid the loss of fine gold by preventing water loss. The sample, and sieving water are collected in a tough polyethylene bag from which most of the air is removed. The sample is allowed to stand for at least 42 hours at which time the clear liquid is removed.

Each sample is not representative of a point source, but is representative of the lithogeochemistry upstream. In an example from the Meat Cove zinc deposit dispersion pilot study (Fig. 2.), downstream dispersion of Zn mineralization is detectable in higher than background values at a distance of 4 km from the source.

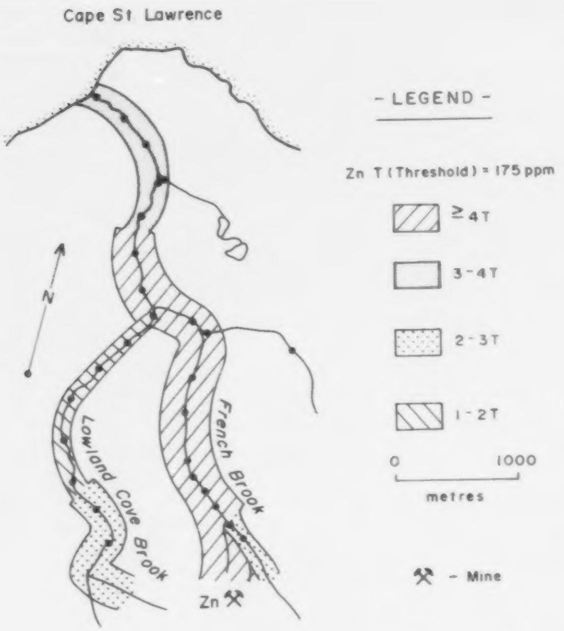
Cape St Lawrence
N
Lowland Cove Brook
French Brook
Zn
- LEGEND -
Zn T (Threshold) = 175 ppm
≥ 4T
3 - 4T
2 - 3T
1 - 2T
0
1000
metres
⚒ - Mine

Figure 2. Downstream dispersion of Zn at Meat Cove, Nova Scotia (modified from Rogers and MacDonald, 1984).

Downstream dispersion from the source may be either mechanical which represents an actual physical movement of mineralized particals by fluvial action, or hydromorphic which represents chemical mobilization and redeposition within the secondary environment. In order to estimate the importance of these factors two different size fractions will be analyzed from each sample.

ANALYTICAL METHODOLOGY

The -230 (fine) fraction or coarse silt to clay sized fraction represents the principal size fraction of hydromorphic dispersion. Within this size fraction, hydromorphic deposition occurs as coatings on grains detectable as the grain area to volume ratio is high. Hydromorphic deposition also prefers the ionic bonding available on negatively charged clay-sized particles. This fraction will be analyzed by directly coupled plasma atomic emission spectroscopy (DCP-AES) (Fig. 3). DCP-AES provides the element combination data useful to the identification of geochemical signatures (Rogers and MacDonald, 1985). Also, trace element analyses were done (by AAS) on stream sediments and this will give additional data to aid in understanding the lithogeochemical input from host lithologies.

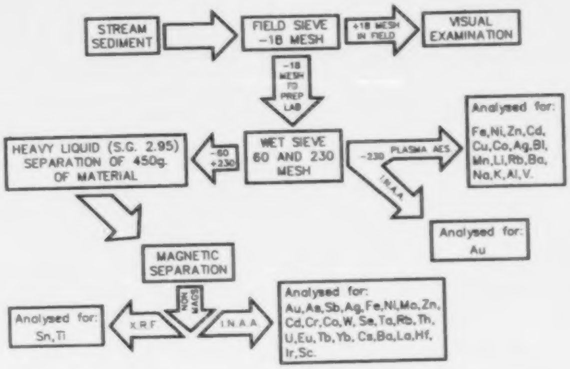
STREAM SEDIMENT
FIELD SIEVE -18 MESH
+18 MESH IN FIELD
VISUAL EXAMINATION
-18 MESH TO PREP LAB
WET SIEVE 60 AND 230 MESH
-60 +230
HEAVY LIQUID (S.G. 2.95) SEPARATION OF 450g. OF MATERIAL
-230
PLASMA AES
I.N.A.A.
Analysed for:
Fe,Ni,Zn,Cd,
Cu,Co,Ag,Bi,
Mn,Li,Rb,Ba,
Na,K,Al,V.
Analysed for:
Au
MAGNETIC SEPARATION
NON MAGS
X.R.F.
I.N.A.A.
Analysed for:
Sn,Ti
Analysed for:
Au,As,Sb,Ag,Fe,Ni,Mo,Zn,
Cd,Cr,Co,W,Se,Ta,Rb,Th,
U,Eu,Tb,Yb,Cs,Ba,La,Hf,
Ir,Sc.

Figure 3. Analytical methodology of the 1986-1987 regional geochemical stream sediment survey.

The -60 +230 (coarse) mesh sized fraction which contains fine sand to coarse silt sized material will undergo heavy liquid separation. These heavy mineral particles which are representative of mechanical dispersion by fluvial means will then be magnetically separated. The non- to para-magnetic fractions will by analyzed by X-ray fluorescence (XRF) for tin and titanium and by induced neutron activation analysis (INAA) for precious and base metals and their granophile, siderophile and chalcophile indicators.

Analysis of stream waters for U and F content by specific ion electrode, for conductivity and pH will aid in the determination of the relative mobility of geochemical indicators within the terrain.

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MINERAL POTENTIAL OF THE DEVONO-CARBONIFEROUS ROCKS IN GUYSBOROUGH COUNTY, NOVA SCOTIA

R. G. Turner and R. R. Stea

INTRODUCTION

This report is a result of work conducted during the Canada-Nova Scotia Mineral Development Agreement as part of the Quaternary Mapping and Till Geochemistry Program for northern mainland Nova Scotia. One aspect of the Quaternary mapping program is to identify areas of exploration interest (based on geochemical anomalies) to aid the mineral exloration industry. Previous regional stream sediment, till and lake sediment geochemical surveys (Boyle et al., 1962; Stea and Fowler, 1979; Bingley and Richardson, 1979) outlined many base metal anomalies in the Havendale - Guysborough area. These anomalies are confirmed by the results of a more recent stream sediment survey (Rogers and MacDonald, 1984).

Follow-up Quaternary mapping in the region led to the discovery of Cu mineralization in the Devono-Carboniferous rocks near Havendale. The purpose of this report is to describe this new occurrence as well as summarize the geology, known mineral occurrences and previous regional surveys in this region.

GEOLOGY AND MINERAL OCCURRENCES

Figure 1 is a simplified geological map of the Havendale - Guysborough area compiled from the work of Schiller (1961) and Keppie (1982). The bedrock geology is predominantly Devono-Carboniferous sedimentary and volcanic rocks including slate, argillite, siltstone, sandstone, conglomerate, basalt, rhyolite and tuff. Unit 1 is a small gabbro body thought to be of Hadrynian age (Keppie, 1982). The rocks comprising Unit 2 are believed to be equivalent in age to the Horton Group (Mississippian). However, this is based on correlation with rocks outside the study area (Schiller, 1961). The rocks in the map area have gone through two deformations and are crosscut by a complex system of faults (Schiller, 1961).

The study area has been glaciated by ice movements to the east, southeast, south and north during the Wisconsinan Stage. The predominate ice flow recorded on striated outcrops is to the southeast (120°-140°). Tills are generally thin, stony and locally derived.

Iron and Cu are the primary mineral deposits of the Havendale-Guysborough area. Specular hematite (Fe) occurs in a number of vein type deposits located along the Milford Haven River (Wright, 1975). Vein type deposits containing Cu are hosted by the sedimentary rocks (Unit 4) near Jake Lakes (MacCormack, 1969). Chalcopyrite and malachite are associated with calcite in fractures, and finely disseminated pyrite occurs throughout the host pelitic rocks.

HAVENDALE OCCURRENCE

The Havendale mineral occurrence is located 5.1 km from Highway 16 on the southern Milford Haven River Road (Fig. 1). A Zn anomaly in the till (sample 87A) located 2 km east of Havendale (Stea and Fowler, 1979) prompted the authors to examine newly exposed rock from road construction.

The mineralized Havendale outcrop extends about 120 m along the road. This section is composed of thick beds of fissile, deformed, green laminated siltstones interbedded with thinner (< 1 m) purple quartzite beds inclined at 165°/60°E. These rocks are finely disseminated with pyrite cubes and blebs. Analysis of a siltstone sample produced values of 390 ppm Zn, 74 ppm Ni, 97 ppm Co, 11 % Fe, 122 ppm As and 7 ppb Au.

Secondary quartz and carbonate veins follow the bedding planes and the major joints (070°/55°S) in the Havendale outcrop. Thin veins (1-2 mm thick) crosscut the laminations and form a stockwork pattern. These vein systems are disseminated with pyrite, hematite, chalcopyrite and malachite. A massive chalcopyrite-pyrite-malachite vein (1 cm thick) continues for 60 cm. Analysis of a vein sample showed 15 ppm Zn, 52 ppm Ni, 13 ppm Pb, 29 % Fe, >20 000 ppm Cu, 82 ppm As and 5 ppb Au.

The A.G.N. Syndicate conducted a soil survey 1 km south of the new occurrence (MacCormack, 1969) but did not find an expression of bedrock mineralization to account for the Cu anomalies. The authors suggest these Cu anomalies were a result of southward or southeastward glacial dispersal from the Havendale Cu occurrence that was unknown at the time of the soil survey.

REGIONAL GEOCHEMISTRY

Till, lake sediment and stream sediment geochemical surveys by Stea and Fowler (1979), by Bingley and Richardson (1979) and Rogers and MacDonald (1984) produced many anomalies in the study area (Fig. 1). Threshold values were determined using the 97th percentile for the till and stream sediment samples (Tables 1 and 2) and the 95th percentile for the lake sediment samples (Table 3). In order to assess the elemental associations in a consistent manner the authors calculated Spearman rank correlation coefficients for all three data sets (Tables 4, 5 and 6).

Till anomalies shown on Figure 1 are predominantly Cu, Ni, Co and Mg. Levels of Sn in most samples are elevated with respect to mean values calculated for the major till types (Table 1). There is an strong association in the data

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

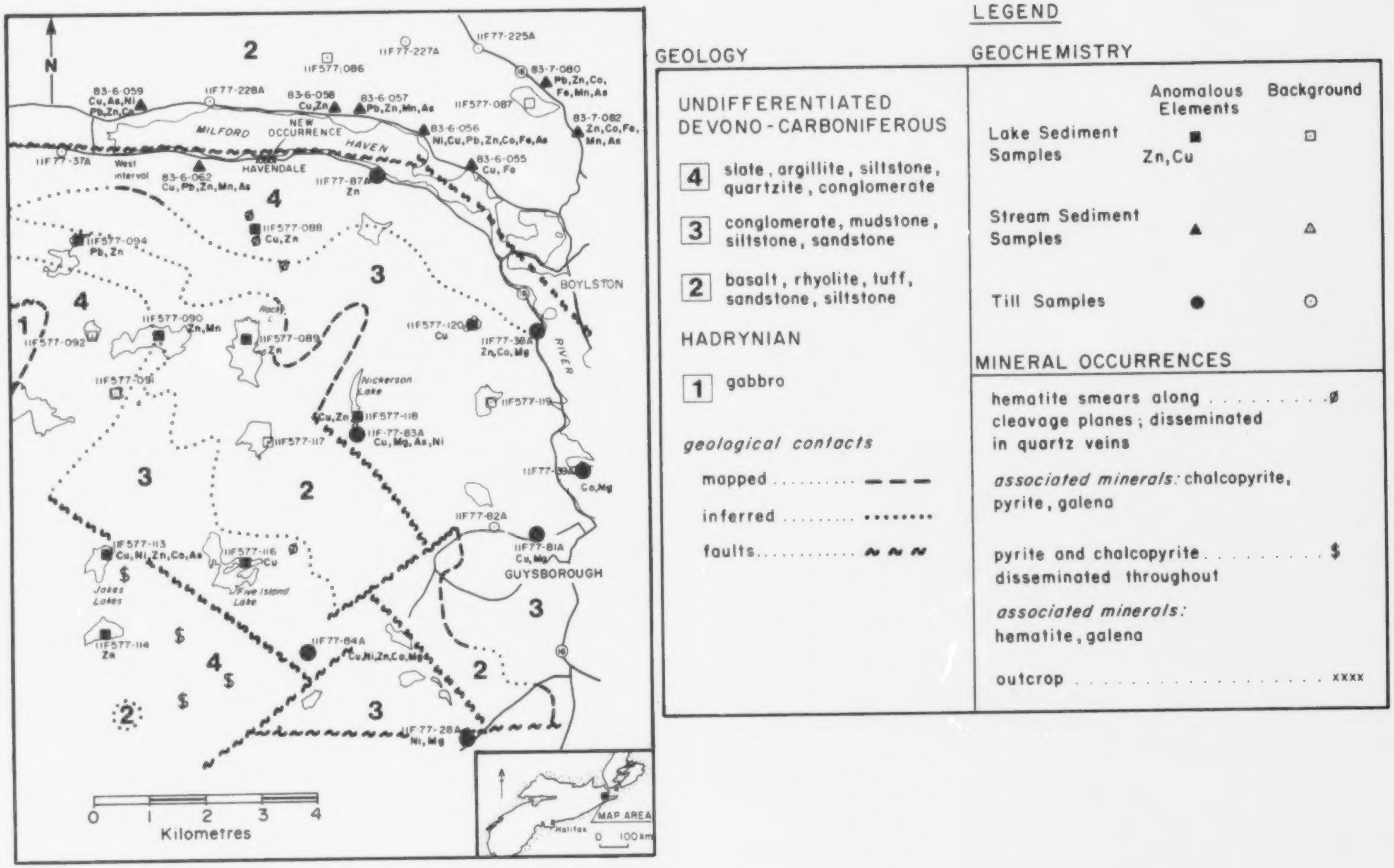
N
2
11F577.086
11F77-227A
11F77-225A
83-7-080
Pb,Zn,Co,
Fe,Mn,As
83-6-059
Cu,As,Ni
Pb,Zn,Co
11F77-228A
83-6-058
Cu,Zn
83-6-057
Pb,Zn,Mn,As
11F577-087
83-7-082
Zn,Co,Fe,
Mn,As
MILFORD
NEW
OCCURRENCE
HAVEN
83-6-056
Ni,Cu,Pb,Zn,Co,Fe,As
11F77-37A
West
interval
83-6-062
Cu,Pb,Zn,Mn,As
HAVENDALE
11F77-87A
Zn
83-6-055
Cu, Fe
4
11F577-088
Cu,Zn
11F577-094
Pb,Zn
3
BOYLSTON
4
1
11F577-092
11F577-090
Zn,Mn
Rocky
L
11F577-089
Zn
11F577-120
Cu
11F77-38A
Zn,Co,Mg
RIVER
11F577-091
Nickerson
Lake
Cu,Zn
11F577-118
11F-77-83A
Cu,Mg,As,Ni
11F577-117
11F577-119
3
2
11F77-39A
Co,Mg
11F77-82A
11F577-113
Cu,Ni,Zn,Co,As
11F577-116
Cu
11F77-81A
Cu,Mg
GUYSBOROUGH
Jakes
Lakes
Five Island
Lake
3
11F577-114
Zn
$
4
$
11F77-84A
Cu,Ni,Zn,Co,Mg
2
16
2
$
3
11F77-28A
Ni,Mg
0 1 2 3 4
Kilometres
MAP AREA
Halifax
0 100 km
LEGEND
GEOLOGY
UNDIFFERENTIATED
DEVONO-CARBONIFEROUS
4 slate, argillite, siltstone, quartzite, conglomerate
3 conglomerate, mudstone, siltstone, sandstone
2 basalt, rhyolite, tuff, sandstone, siltstone
HADRYNIAN
1 gabbro
geological contacts
mapped .... — — —
inferred .... ••••••••
faults.......... ~ ~ ~
GEOCHEMISTRY
Anomalous Elements
Background
Lake Sediment Samples
Zn,Cu
Stream Sediment Samples
Till Samples
MINERAL OCCURRENCES
hematite smears along cleavage planes; disseminated in quartz veins ....Ø
associated minerals: chalcopyrite, pyrite, galena
pyrite and chalcopyrite disseminated throughout .... $
associated minerals: hematite, galena
outcrop xxxx

Figure 1. Geological and geochemical map of the Havendale-Guysborough area

Table 1. Lake geochemical data

SAMPLE	Cu*	Ni	Pb	Zn	Co	Fe (%)	Mn	Ca	Mg	As	Hg (ppb)
11F77225A	63	44	26	170	17	5.82	1280	48	7220	1	16
11F77227A	63	46	26	184	19	6.76	1560	292	7040	26	11
11F77228A	40	39	24	206	11	6.14	580	119	6520	10	11
11F7728A	84	105	8	246	42	4.24	11360	3380	47400	5	-
11F7737A	71	72	56	306	48	5.94	6160	316	20000	-	-
11F7738A	91	60	38	268	30	5.64	1920	542	19200	6	14
11F7739A	86	61	42	234	29	5.20	1660	138	19600	4	20
11F7781A	119	63	22	154	28	4.12	2560	208	16800	4	30
11F7782A	137	65	30	172	34	4.48	3480	322	17000	-	-
11F7783A	516	109	86	376	53	4.12	4780	964	20400	30	34
11F7784A	144	73	38	266	36	5.60	3240	352	25600	6	22
11F7787A	92	47	34	318	19	5.28	1860	110	14160	11	8
LAWRENCETOWN TILL											
Mean**	65	48	33	186	19	6.30	2146	200	8009	14	20
Threshold	103	67	114	265	29	8.90	4066	1228	13406	51	40
UPLAND TILL											
Mean	109	51	74	232	29	7.00	4460	210	9174	12	33
Threshold	361	100	268	456	68	12.00	11370	956	20528	35	94

*all values in ppm except where indicated

**mean and threshold values (mean + 2 standard deviations) were calculated for each till type identified in Stea and Fowler (1979) in the Guysborough area; samples 225, 227, 38, 39, 81, 84 87 are from the Lawrencetown Till, a red clay till; samples 228, 28, 37, 82, 83 are from stony, local tills called upland till.

set among Cu, Ni, Co, Mn and Mg (Table 4). Pb, Zn and Co form a separate association of positively correlated elements. Fe values are negatively correlated with the anomalous elements. This suggests that scavenging by iron oxides, through soil processes within the till, is not a major influence on the element levels and associations. The highest metal values in the till samples are near Nickerson Lake (sample 83A) with Cu, Ni and Zn values of 516 ppm, 109 ppm and 376 ppm, respectively (Fig. 1, Table 1).

Stream sediment data from the map area show many Pb-Zn anomalies with Zn values generally over 100 ppm compared to a threshold value of 89 ppm (Table 2). The Cu, Ni and As levels are strongly associated as are Pb and Zn levels (Table 5). The Fe and Mn levels are positively correlated with Co, As and Hg levels. This may be an effect of the coprecipitation or adsorption of these metals with Fe and Mn oxides.

Lake sediment samples show a predominance in Zn anomalies with a high value of 738 ppm in a sample near Jake Lakes and a threshold value of 168 ppm (Fig. 1, Table 3). Cu and Pb mineralization is known in this region (Fig. 1). Cu and Ni are correlated as in the till and stream sediment data sets (Table 6). Fe and Mn levels are associated with Zn levels suggesting some of the anomalies may be nonsignificant. Zn levels may be enhanced through scavenging by Fe and Mn oxides in the lake bottoms. Zn anomalies in the till and nearby stream sediments that do not correlate with Fe and Mn, imply the Zn anomalies observed in the lake sediments are significant.

Table 2. Stream geochemical data

Sample	Cu*	Ni	Pb	Zn	Co	Fe (%)	Mn	As	Hg (ppb)
83-6-055	21	29	16	65	10	3.3	1020	6	20
83-6-056	28	43	22	200	31	4.0	7100	25	50
83-6-057	15	27	20	105	20	2.8	3500	16	30
83-6-058	18	26	17	117	13	2.6	1220	11	20
83-6-059	33	36	29	172	24	3.1	2750	40	50
83-6-062	19	27	30	200	20	2.5	3400	18	40
83-6-066	12	22	22	65	10	3.3	1020	6	20
83-6-068	12	29	42	248	18	2.2	2600	11	30
83-7-080	15	24	25	138	48	4.0	7800	16	40
83-7-082	12	24	13	135	72	3.8	6900	15	40
Mean**	14	28	14	79	18	2.9	2529	9	40
Threshold***	15	32	17	89	20	3.0	3057	10	45

*all values in ppm except where indicated

**mean and threshold values from Rogers and MacDonald, 1984

***mean + 2 standard deviations

Table 3. Lake geochemical data

Sample	Cu*	Ni	Pb	Zn	Co	Fe (%)	Mn	Ca	Mg	As	Hg (ppb)
11F577-086	12	11	2	54	1	0.30	116	3460	1100	4	1
11F577-087	12	14	2	92	4	1.02	244	2000	3080	3	32
11F577-088	78	22	2	328	7	0.24	524	4240	640	8	44
11F577-089	22	30	2	198	15	1.38	636	3280	1980	7	20
11F577-090	14	22	12	208	14	2.18	1006	760	3380	6	16
11F577-091	22	9	6	94	1	0.06	60	3400	780	3	12
11F577-092	12	6	10	82	1	0.08	52	1120	780	4	16
11F577-094	18	18	26	312	3	0.18	54	3980	1060	2	32
11F577-113	48	38	16	738	28	2.12	812	2700	2780	16	12
11F577-114	29	14	10	322	9	1.60	716	2320	1220	5	32
11F577-116	53	30	2	116	12	1.86	422	4180	1580	4	12
11F577-117	14	17	2	138	5	0.66	560	4420	2420	4	32
11F577-118	72	22	4	198	8	0.52	716	4620	2540	5	12
11F577-119	28	31	2	100	15	0.60	520	4840	1480	3	52
11F577-120	42	21	2	54	8	0.36	122	1240	1180	4	32
Mean**	14	15	10	71	7	1.00	319	2227	1380	5	40
Threshold***	29	38	26	168	22	3.50	936	5540	4240	15	100

*all values in ppm except where indicated

**mean and threshold values from Bingley and Richardson, 1979

***95th percentile

Table 4. Matrix of Spearman correlation coefficients for till

	Cu	Ni	Pb	Zn	Co
Cu	1.000				
Ni	0.678	1.000			
Pb	0.411	0.351	1.000		
Zn	0.315	0.427	0.684	1.000	
Co	0.552	0.944	0.512	0.524	1.000
Fe	-0.753	-0.662	-0.014	0.067	-0.459
Mn	0.538	0.930	0.235	0.413	0.916
Ca	0.455	0.797	0.196	0.399	0.846
Mg	0.545	0.916	0.396	0.503	0.895
As	0.049	-0.109	0.098	0.459	-0.116
Hg	0.420	0.092	0.246	-0.039	-0.011
	Fe	Mn	Ca	Mg	As
Fe	1.000				
Mn	-0.564	1.000			
Ca	-0.392	0.783	1.000		
Mg	-0.529	0.839	0.769	1.000	
As	0.084	-0.245	0.130	-0.137	1.000
Hg	-0.318	-0.212	-0.032	0.067	0.311

Note: n=12; correlations >.5 = Cu-Ni-Co-Mn-Mg, Ni-Ca, Pb-Zn-Co, Zn-Mg, Co-Ca, Mn-Ca, Ca-Mg; negative correlations >.5 = Fe-Cu-Ni-Mn

There is a consistent decrease in the correlation coefficients for Pb and Zn between the till (0.684), stream sediment (0.656), and lake sediment (0.483) sampling mediums. The relatively high correlation of Pb and Zn in the till and stream sediments implies hydromorphic and chemical redistribution of these elements is not a major factor in these mediums. Pb and Zn are not associated in the lake sediments suggesting the above factors may be responsible for the enhancement of mobile Zn relative to immobile Pb in this medium. This may account for the many Zn anomalies observed in the lake sediment samples (Fig. 1, Table 3). The low Pb concentrations observed in the lake sediments are likely due to the relatively insoluble nature of Pb in the surficial environment and its inability to be transported by water from till and bedrock to the lake sediments.

MINERAL POTENTIAL

The known mineral occurrences and the available data from numerous geochemical surveys makes the Devono-Carboniferous strata of the Havendale - Guysborough area a target for base metal exploration. Chalcopyrite, galena, and specular hematite are known to occur in this area. Till, and stream and lake sediment geochemical surveys outlined anomalies of Cu, Ni, Pb, Zn, Co, Fe, Mn, Mg and As. These multi-element anomalies are spatially associated with known mineral occurrences (Fig. 1). The Jake Lakes area is mineralized with chalcopyrite and minor galena. The adjacent lakes are anomalous in Cu, Zn, Ni, Co and As. The presence of Zn anomalies in the lakes suggests that this metal may be part of the Cu and Pb occurrences and is as yet not identified, or it may form a separate occurrence. Metal associations in the data sets (Tables 4, 5 and 6) also suggest that Zn may be part of two distinct deposit types. Cu is associated with Ni, Co and As in the geochemical data sets. Vein type Cu mineral occurrences such as the Havendale showing are predominantly pyrite and chalcopyrite. Pyrite could contribute Ni and Co to the secondary environment to explain the concordant responses of these metals with Cu. Zn levels in the host rocks of this occurrence are elevated, explaining the Zn anomalies in the streams, lakes and tills of the area. Pb and Zn levels are strongly correlated in the till and stream data sets. Pb and Zn anomalies supplant Cu, Ni and Zn anomalies in the northwest section of the map area (Fig. 1). This may reflect a zonation in one deposit type over the map area or a separate environment. MacCormack (1969) describes galena in quartz veins associated with slates south of the Milford Haven River west of the map area. Zn minerals may be present in these occurrences but as yet have not been identified.

Copper and Ni anomalies in till near Nickerson Lake (in addition to Cu and Zn anomalies in the lake) may reflect mineralization near the volcanic/metasedimentary (Unit 1/Unit 2) fault contact. The known occurrences and geochemical anomalies appear to be spatially related to faults and volcanic/sedimentary contact zones. These areas should be the targets for more detailed base metal surveys.

Table 5. Matrix of Spearman correlation coefficients for stream sediments

	Cu	Ni	Pb	Zn	Co
Cu	1.000				
Ni	0.701	1.000			
Pb	0.161	0.331	1.000		
Zn	0.162	0.476	0.656	1.000	
Co	-0.072	-0.090	-0.222	0.402	1.000
Fe	0.049	-0.203	-0.445	-0.145	0.566
Mn	0.023	-0.025	-0.066	0.441	0.894
Ca	.	.	.	.	.
Mg	.	.	.	.	.
As	0.542	0.455	0.250	0.608	0.632
Hg	0.398	0.397	0.364	0.710	0.706
	Fe	Mn	Ca	Mg	As
Fe	1.000				
Mn	0.611	1.000			
Ca	.	.	.		
Mg	.	.	.	.	
As	0.187	0.639	.	.	1.000
Hg	0.323	0.706	.	.	0.863

Table 6. Matrix of Spearman correlation coefficients for lake sediments

	Cu	Ni	Pb	Zn	Co
Cu	1.000				
Ni	0.664	1.000			
Pb	-0.064	-0.097	1.000		
Zn	0.496	0.506	0.483	1.000	
Co	0.501	0.874	-0.010	0.494	1.000
Fe	0.154	0.558	0.027	0.403	0.792
Mn	0.404	0.605	0.112	0.656	0.761
Ca	0.411	0.379	-0.363	0.159	0.018
Mg	-0.066	0.419	0.028	0.192	0.563
As	0.334	0.377	0.102	0.520	0.487
Hg	0.076	0.109	-0.233	0.168	0.140

	Fe	Mn	Ca	Mg	As
Fe	1.000				
Mn	0.792	1.000			
Ca	-0.189	0.034	1.000		
Mg	0.820	0.689	-0.129	1.000	
As	0.425	0.694	-0.195	0.229	1.000
Hg	-0.066	0.001	0.143	-0.138	-0.162

Note: n=15; Correlations >.5 = Cu-Ni-Co, Ni-Zn-Co-Fe-Mn, Co-Mg, Fe-Mg, Mn-As

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THE GARDEN OF EDEN DISPERSAL TRAIN*

R. G. Turner and R. R. Stea

INTRODUCTION

This study is part of the surficial mapping program carried out under the Canada-Nova Scotia Mineral Development Agreement. The Garden of Eden study area is located on the southern edge of the Antigonish Highlands, adjacent to the St. Marys Graben in Pictou County, Nova Scotia. The purpose of this study is to determine the net effect of glacial dispersal during the four major ice flow events that affected the area.

GEOLOGY

The Eden Lake Complex is a late Precambrian rock suite composed of appinite, hornblende syenite, pegmatite and microgranite. East of Eden Lake these rocks are in contact with the Ordovician Bears Brook Formation composed of red arkosic sandstone, conglomerate, rhyolite tuff and minor basalt. West of Eden Lake the complex is in contact with Silurian blue-grey shales and siltstones of the Ross Brook Formation (J. B. Murphy, 1985). The Eden lake Complex is very distinctive and easily recognized in the background of sedimentary and felsic volcanic rocks.

PREVIOUS WORK

The majority of previous glacial dispersal studies in Nova Scotia have been conducted on the Meguma Terrane south of the present study area and deal with the dispersal of tin, tungsten and gold in till. The dispersal patterns of mineralized debris from their source deposits are southward and southeastward trending unidirectional or lobate fans (Prest, 1911; Wilson and Richardson, 1980; DiLabio, 1982; MacEachern and Stea, 1985; Turner, 1986).

A Late Wisconsinan (Scotian) ice divide extends across the axis of southern Nova Scotia on the Meguma Terrane (Grant, 1977; Stea and Finck, 1984). Little movement occurs in an ice sheet near an ice divide (Denton and Hughes, 1981) and as such the Meguma Terrane exhibits little geomorphological evidence of this ice divide. Erosional and depositional evidence (striations, and till and erratic boulders, respectively) of ice movement attributed to the Scotian ice divide, however, is found in northern Nova Scotia (Stea and Finck, 1984). Dispersal studies done in areas north of the Meguma Terrane have determined the effect of northward flow from the Scotian ice divide (Bailey, 1898; Hickox, 1962).

Stea and Finck (1984) also postulated an ice centre in the Antigonish Highland region east of the Garden of Eden based on the distribution of striations and erratic boulder dispersal. This centre of flow developed after the Scotian ice divide.

The following factors present the Garden of Eden as a unique situation in the study of the effects of glacial dispersal:

- the location north of the Scotian ice divide and west of the proposed Antigonish Highland centre of flow,
- the record of four ice flows, and
- the distinctive rock types comprising the Eden Lake Complex.

METHODOLOGY

Quantitative data to determine the effect of glacial dispersal in the Garden of Eden area was collected from three sources: 1) fence boulder piles in farm fields, 2) lag boulders washed out of till sections, and 3) pebble counts from previously collected till samples. In each case, 150-200 boulders or pebbles were counted and % appinite clasts determined. A total of 51 boulder piles and till lag sites were counted. Till sample pebble counts were used only where either boulder piles or lag sites were absent. The % appinite clasts is generally lower in the till samples. These samples represent a much smaller sampling area and are occasionally taken from basal tills rich in local debris. The fence boulder piles provided the most accurate counting method as the lichen covering disguised the stones and eliminated bias.

DISCUSSION

The relative ages of the four major ice flows that traversed the Garden of Eden are recorded at two striation sites near Eden Lake. A summary of these flows from oldest to youngest is (1) N140E, (2) N165E, (3) N005E and (4) N220E. The major ice flow trends indicated by striations (Fig. 1) are also displayed by the mapped glacial dispersal pattern of appinite erratics (Fig. 2, Table 1).

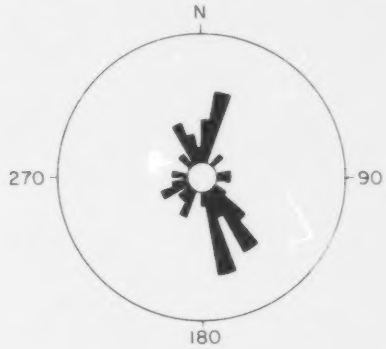

Figure 1. Plot of all measured striations of known ice flow direction

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*Funded by Geological Survey of Canada and Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

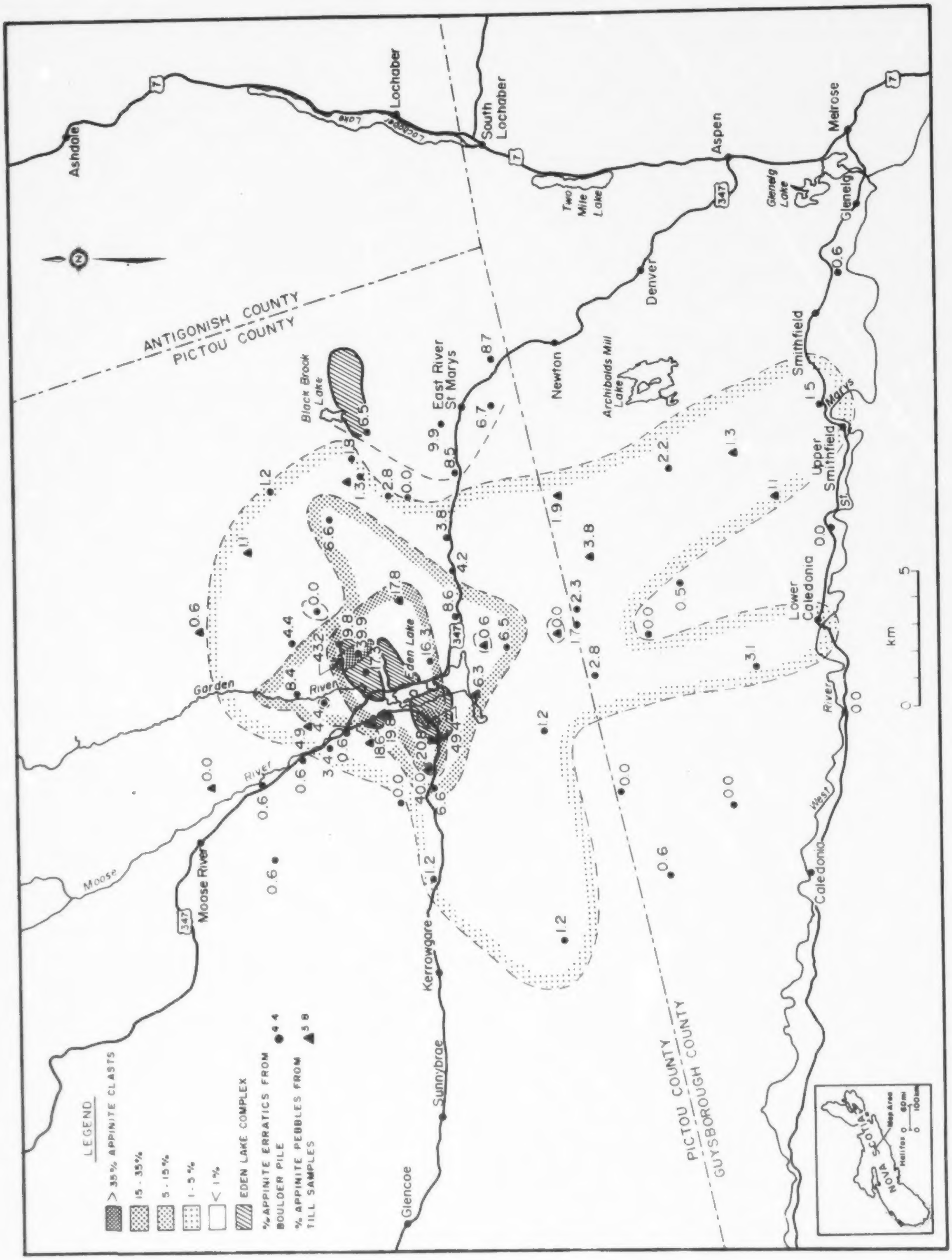
LEGEND
> 35% APPINITE CLASTS
15 - 35%
5 - 15%
1 - 5%
< 1%
EDEN LAKE COMPLEX
% APPINITE ERRATICS FROM BOULDER PILE ● 4.4
% APPINITE PEBBLES FROM TILL SAMPLES ▲ 3.8
ANTIGONISH COUNTY
PICTOU COUNTY
GUYSBOROUGH COUNTY
Ashdale
Lochaber
South Lochaber
Lochaber Lake
Two Mile Lake
Aspen
Glenelg Lake
Glenelg
Melrose
Denver
Newton
Archibalds Mill Lake
Smithfield
Upper Smithfield
St. Marys River
Lower Caledonia
Caledonia
West River
East River St Marys
Black Brook Lake
Eden Lake
Garden River
Moose River
Kerrowgare
Sunnybrae
Glencoe
7
347
km
0
5
NOVA SCOTIA
Map Area
Halifax
60mi
100km

Figure 2. Appinite dispersal pattern in the till surrounding the Eden Lake Complex; each data point represents % appinite clasts.

Table 1. Dispersal characteristics

AZIMUTH	% APPINITE	EXTENT (km)	SHAPE
140-160	1-5	-	lobe
	5-15	5	lobe
170-180	1-5	15-20	lobe
080-350	1-5	7-8	broad fan
	5-15	4-5	lobe
225-250	1-5	10	broad fan
	5-15	2	lobe

The 1-5% contour indicates a four-directional trend similar to the striation directions. The long southeast (140°-160°) and south-southeast (170°-180°) dispersal lobes are clearly the dominant patterns. The maximum extent of the 140°-160° trending dispersal lobe is not known as it intersects with dispersal from the appinite complex near Black Brook Lake. The 170°-180° trending dispersal lobe may be the result of a slight directional shift in the major southeast Wisconsinan ice flow that occurred throughout Nova Scotia. Appinite boulders are dispersed northwest to northeast (080°-350°) and southwest (225°-250°) of the Eden Lake Complex in the form of broad fans. The northward dispersal fan is a result of changes in flow during the northward ice movement. Northward striations measured over the map sheet area form two distinct groups trending 330°-350° and 0°-20°, respectively (Fig. 1). The southwestward striations trend 200°-250°. The magnitude and the extent of the southwestward and northward dispersal fans is small compared to the southeastward lobes.

The 15-35% contour of appinite clasts surrounds the Eden Lake Complex and has only 0.5-2 km of dispersal over adjacent rocks. Two areas located directly over the Eden Lake Complex, with no apparent dispersal, have >35% appinite clasts. These areas are thought to be coincident with zones of appinite in the Eden Lake Complex. A third area with >35% appinite clasts is located about one kilometre west of the mapped complex. It may suggest the presence of another unmapped appinite complex.

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MICROCOMPUTER BASED DATABASE APPLICATIONS FOR MINERAL EXPLORATION AND MINING*

I. G. Burns and J. M. Patterson

The former copper - lead - zinc - silver - barite producer at Walton, Hants County, Nova Scotia is one of the deposits to be studied as part of the Base Metal Project at Nova Scotia Department of Mines and Energy (NSDME). A major world barite producer from 1941 to 1975, Walton also produced significant quantities of copper, lead, zinc and silver. Approximately 360,000 tons of sulphide ore were milled between 1961 and 1974 at an average head grade of 0.7% Cu, 5.0% Pb, 1.7% Zn and 12 oz Ag/t. Recent examination of the deposit shows the mineralization to be open at depth and the presence of high grade silver values on the 1650 ft level (the deepest mine workings) demanded that further investigations be undertaken.

Geologically the Walton deposit is situated at the Horton Group/Windsor Group contact where east-west and northwest-southeast trending faults cut the Macumber and Pembroke Formations of the Lower Carboniferous Windsor Group. Sediments of Carboniferous age are host to important base metal deposits in Nova Scotia and several former producers have contributed significantly to the economy of the Province.

As a result of the long history of mining at Walton a large volume of data is available. Geological logs and assay records from approximately 650 underground and 130 surface drillholes are available. Computer manipulation was deemed necessary to produce a proper evaluation of these data within a reasonable time frame. This evaluation will examine metal distribution patterns and relate these to reconstructed pretectonic paleotopography in an attempt to investigate the relationship between these two factors. Due to the presence of five elements of economic significance the program converts metal content from percentages and ounces to dollars, thereby allowing the economic aspects to be more readily examined. In addition the program will permit sections and plans of geological and assay data to be drawn and will also allow statistical relationships between metals to be investigated.

To assist in achieving the above a menu-driven database management system has been developed using the programming language dBASE 111+. This system which offers record management facilities (addition, deletion, editing and retrieval of records) has been expanded to perform additional functions.

The location data together with the azimuth and dip of the hole (Fig. 1) will allow assay and geological information to be plotted through depth thus permitting the construction of three-dimensional diagrams.

Level and DDH#:	033001
Is this a quarry?	F
Latitude:	1833
Longitude:	3000
Elevation:	1638
Azimuth:	0
Dip:	0
Total Depth (ft.):	225
Horton:	18
Windsor:	

Figure 1. Locations and geological data entry format

The assay information is entered as shown on Figure 2. All available assays are entered so that statistical investigation can be undertaken and any correlations quantified. The degree of correlation, if any, between metal content and the sideritic unit as expressed by the assay data for FeO and Fe_2O_3, is an example that may be investigated.

ASSAY INFORMATION

Level and DDH#:	0330001
Start depth (ft):	76.5
End depth (ft):	87.5
Au (troy ounces/ton):	0.00
Ag (troy ounces/ton):	20.00
Cu (%):	0.76
Pb (%):	49.36
Zn (%):	2.73
Cd (%):	0.00
$BaSO_4$ (%):	0.00
FeO (%):	0.00
Fe_2O_3 (%):	0.00
CaO (%):	0.00
MgO (%):	0.00
SiO_2 (%):	0.00

Figure 2. Assay information entry format

Due to the polymetallic nature of the Walton deposit it was decided to express cut-off values in dollar terms. Such an approach allows a simple presentation of one value for the cut-off rather than complex combinations of 5 metals having economic values which change independently of each other. The dollar value approach also allows the investigator to consider different 'what if' scenarios and also to take into consideration fluctuations in metal prices and mining costs.

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

The following routine is used to obtain a doller cut-off value:

1. % metal content is converted to lbs/ton or lbs/tonne.

2. Current metal prices, which are stored in the program (Fig. 3) and can be updated at any time, are applied and the pounds of contained metal are converted to dollar amounts. It should be noted that all calculations are in $US as this is the currency in which metals are priced. The metal pricing program contains the current $CND conversion so that the figures generated can be expressed in Canadian funds.

```
The last recorded price fix date was: 10/29/86
The last recorded prices are (in $US):
Canadian Dollars: 0.7205
Pounds Sterling:  1.4125

Copper (lb):        0.633
Gold (oz):        407.000
Silver (oz):        5.580
Lead (lb):          0.255
Zinc (lb):          0.500
Cadmium (lb):       0.000
```

Figure 3. Metal prices and exchanges rates to allow presentation of metal contents in dollar terms

3. The dollar values for each metal are calculated and the total dollar value of the 4 metals (Cu, Pb, Zn and Ag) are displayed for the intersection chosen (Fig. 4). This approach can then be extrapolated to drillhole scale and ultimately to the scale of the deposit.

4. To allow a rapid first pass evaluation the cut-off can be expressed as a dollar value and applied to a drillhole. All intersections at or greater than the cut-off will then be shown and a first estimate of commercial viability can be made rapidly.

5. The relative contribution of each metal to the total dollar value can be displayed for any intersection or group of intersections up to and including the deposit scale (Fig. 5). Thus fluctuations in metal prices, which will change the contribution of each metal to the total value, can be considered. This is an important function for the investigator, as deposits which historically were base metal producers with a minor economic benefit from the contained precious metals, may become primary precious metal deposits due to significant price changes. Such is indeed the case with the Walton deposit. The 12 oz Ag/t content which contributed approximately US$13 per ton during the mining operations is worth US$66 per ton today.

6. In an attempt to give greater flexibility to an initial investigation of a deposit, the geologist can consider intersections below cut-off grade which are either bracketed by ore grade intersections, or immediately preceed or succeed ore grade intersections. In the case of a preceeding or succeeding intersection the investigator can set the minimum grade or value to be considered for incremental purposes so as not to over dilute a high grade intersection. Thus the incremental cut-off can be varied so that an investigator can maximize width without over-dilution of grade (Fig. 6).

7. The final products of these investigations are displayed on the monitor and this allows the investigator to select the start and end points from which a hard copy report can be produced. This report will show the individual assay values comprising the interval chosen, and a weighted grade for this interval will be produced.

Departmental acquisition of IBM personal computers facilitated the development of programs to improve access to and aid in the analysis of large volumes of data. The Walton Mine data bank, comprising mainly drillhole logs and associated plans and sections, lends itself well to

```
LEVEL:  0690  DDH#:  174  FROM(ft)  Cu($)     Pb($)    Zn($)      Ag($)     Total $

                             0.0     0.000     0.000    0.000      0.000      0.000
                            63.0     1.760     0.680    0.000     34.070     36.510
                            75.0     2.520     3.600    0.000     25.330     31.450
                            87.5     0.500    19.710   58.780     32.220    111.220
                            95.0     0.500    42.080   91.080     54.470    188.130
                           100.0     9.070    80.280   40.480   2572.750   2702.580
                           110.0    20.920    99.230   15.750   1635.310   1771.200
                           117.0     8.690    40.500   27.460    509.080    585.730
                           125.0     0.630    72.670  108.680     69.870    251.860
                           135.0     0.000     0.000    0.000      0.000      0.000
                           169.0     0.000     0.000    0.000      0.000      0.000

At a cutoff of $50.00 U.S. the limits for commercial production are: 75.0 to 95.0,
75.0 to 100.00, 75.0 to 110.0, 75.0 to 117.0, 75.0 to 125.0, 75.0 to 135.0
The above values were calculated using closing prices as of 09/03/86
Would you like to check another drillhole ? (y/n)
```

Figure 4. Metal values expressed in dollar terms

```
                DDH INTERSECTION DOLLAR VALUES OF METALS
             WITH RELATIVE PERCENTAGES BASED ON TOTAL VALUE

LEVEL:  0690  DDH#:  174      FOR 10.0 FT     FROM 100.0 FT TO 110.0 FT

ASSAY RESULTS                DOLLAR VALUE                 % TOTAL VALUE

Copper (%):          0.72   Copper ($US):       9.070    Copper (%):      0.3
Lead (%):           17.84   Lead ($US):        80.280    Lead (%):        2.9
Zinc (%):            4.60   Zinc ($US):        40.480    Zinc (%):        1.5
Silver (oz):       474.24   Silver ($US):    2572.750    Silver (%):     95.2
Gold (oz):           0.00   Gold ($US):         0.000    Gold (%):        0.0
Cadmium (%):         0.00   Cadmium ($US):      0.000    Cadmium (%):     0.0

                          Total Value: 2702.580
```

Figure 5. Metal values in % and oz (converted to dollar terms) and the relative of each metal contributes to the total value

manipulation by a database management package. The dBASE III+ system and the computer/software combination is an economical means of accomplishing this goal.

The application program is a modular design and allows interchange of individual modules between programs. It can also be adapted to perform similar tasks for other data packages simply by appropriately amending references to data files and fields. The program was developed using the IBM version of dBASE III+ and will run on an IBM-PC or true compatible having at least 328K of RAM and dual 360K floppy drives. A hard drive may be desirable for speed of access and to accomodate large data sets. However, the minimum configuration described above can manage the data from over 750 drillhole records containing 2700 associated assay records with each record containing up to 12 assay results.

To date these programs have been applied to the Walton and Yava deposits. Eventually proper merging of these data with appropriate plotting hardware will allow the main objective, namely the investigation of the modes and environments of emplacement of the deposits, to be achieved.

```
DDH:403 CUTOFF 3.00% SAMPLE# FROM(ft)  TO(ft)  WIDTH Pb %  ft% Pb  Zn % ft% Zn  Ag(oz)  ft oz/t Ag

                      2504    14.3     17.9    3.6  6.5   23.47   0.0  0.18    0.0       0.32
                      2505    17.9     19.9    2.0  2.0    4.00   0.1  0.36    0.0       0.12
                      2506    19.9     23.1    3.2  5.3   17.02   0.0  0.13    0.0       0.03
                      2507    23.1     28.1    5.0  3.0   15.00   0.0  0.15    0.0       0.10
                      2513    28.1     33.1    5.0  2.8   14.20   0.0  0.15    0.0       0.40

           TOTAL WIDTH: 18.8   Pb Wtd. Avg.: 3.92   Zn Wtd. Avg.: 0.05   Ag Wtd. Avg.: 0.05
```

Figure 6. Ore grade over a width incorporating values below cut-off grade brackets by and incremental to values above cut-off

NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY COMPUTER DEVELOPMENT*

D. W. Rigby

INTRODUCTION

In April 1986, the Nova Scotia Department of Mines and Energy (NSDME) took a major step forward in the development of its in-house computer capacity. Twelve micro-workstations were acquired as part of the first phase of a five year computer development plan. In-house training for microsystem operators and for users was initiated as part of the first phase. User support and application development in Lotus and Dbase3 as well as other software was developed in the effort to harness this new microcapacity for database development, scientific analysis, report generation and word processing.

DATABASE REPATRIATION AND DEVELOPMENT

Before 1986 NSDME was largely dependent on external mainframe and minicomputers (Tables 1 and 2). All bibliographic, geological and geochemical data were stored on these external computers.

Some of these databases are quite large. The Geoscan bibliography on the HP 3000 at Energy, Mines and Resources Canada in Ottawa is presently 16 million bytes and is estimated to grow to 22 million bytes by 1990. Others, such as the Industrial Mineral database on the DEC 1173 at the Maritime Resources Management Service in Amherst, are quite small. It is presently 300,000 bytes and will rise to 1.5 million bytes by 1990. The plan calls for progressively repatriating these databases in order to integrate and make them more accessible within the Department.

In addition to the above, there are a number of databases within the Department including the licensing and leasing procedures, and the statistical analysis of data in the Registry of Mineral and Petroleum Rights which need to be automated. In the Mineral Resources Division dozens of new databases exist on the micro-computers. As an example, chemical analyses can be transferred directly from the laboratories via modem or floppy disk. These data are extracted and manipulated using Word Perfect and entered directly into a Lotus worksheet or Dbase file without rekeying. From this point the data can be reformatted and transferred to other graphic and statistical programs for analysis. Results from this analysis can be transferred directly to the final report using Word Perfect.

Table 1. Nova Scotia Department of Mines and Energy computer equipment

EQUIPMENT	BEFORE 1986	ADDITIONAL IN 1986	ADDITIONAL BY 1990
External Computers			
Dalhousie University, Halifax	Cyber 170-730 (on line)		
Maritime Resources Management Service, Amherst	Dec 1173		
Energy, Mines and Resources, Canada in Ottawa, Ontario	HP 3000 (on line)		
Energy, Mines and Resources, Canada in Calgary, Alberta	HP 3000 (on line)		
Internal Computers			
Minicomputer	Data General Nova Single task, 4 users	replaced by IBM AT	Multitask, 12 users
Microcomputer	1 Compaq Deskpro 3 1 IBM PC 4 Osborne	6 IBM AT 8 IBM XT	5 IBM compatible AT 6 IBM compatible XT

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

Table 2. Nova Scotia Department of Mines and Energy computer system summary

ASPECT OF SYSTEM	BEFORE 1986	1986	PLANNED FOR 1990
Tasks	input/edit data; develop/run programs on external computers	repatriate databases and programs from external computers; develop Lotus and Dbase3 applications	develop communication network between mini- and micro-computers; repatriate large databases; develop GIS/DBMS applications on minicomputer
Databases	disbursed on external computers or developed manually	download or develop on microcomputers	download or develop on mini- and microcomputers
Hardware	dependent on external mainframe and minicomputers for data processing; stand-alone Micom word processors	14 micro workstations; linkage between micro-computers and Micom word processors; micro plotter	microcomputers linked to internal minicomputer data and word processors fully integrated; 36" plotters
Software	Fortran and Basic, statistical and graphics packages	Lotus, Dbase3, Micro statistics, Crosstalk and Wordperfect	Mini Geographic Information System/Database Management System (GIS/DBMS)
Computing Staff	2 divisional, 4-6 summer students	1 departmental 2 divisional, 8 summer students	2 departmental, 3 divisional, 4-6 summer students
Decision Making Structures	Ad-Hoc Computer Committee: participation in consultant study	structured MIS Working Group: 5 year planning, equipment, training and database subcommittees	same committees
Department Training	informal- user instruction on Dalhousie University Cyber's user libraries	microsystem operators; Wordperfect, Lotus, Dbase3 users	Mini GIS/DBMS, communication network users

REPLACEMENT OF EXISTING COMPUTER EQUIPMENT

Before 1986, NSDME had some internal computing equipment. This included a four terminal, single task Data General Nova minicomputer used by the Energy Management Division in its program of on-site analysis of energy usage in government and small businesses. Both this and the five Osborne microcomputers used in this program are considered obsolete and require replacement with IBM compatible computers.

The Department also has six stand-alone Micom word processors. Three of these are the older 2001 model. The plan calls for their replacement by IBM compatible microcomputers.

TRAINING AND USER SUPPORT

In April 1986, informal introductory classes on three software packages were held for voluntary system operators. These have been formalized into separate ongoing courses for general users. Each course consists of two three-hour sessions (Table 3). The first class is separated from the second by five days to allow students to use the self-instructional lessons offered in each software package. These sessions are repeated every one to two months to a new group and will continue as long as there is a demand.

A series of ongoing users groups were developed for introductory course graduates. These are designed to help users to apply the software to

Table 3: Introductory courses and users groups

INTRODUCTORY COURSES	USERS GROUPS
-	System Operators
Microcomputers and Word Perfect	Word Perfect
Lotus	Lotus
Dbase3	Dbase3 Dbase3 Programmers

specific applications and to share experiences and knowledge drawn from external sources.

With only two computer staff among 160 employees, the demand for specific applications in Lotus and Debase has been met by recruiting summer programmers. The plan calls for the expansion of full-time computer staff by two Department level positions.

COMPUTER PLANNING PROCESS

In 1985, the opportunity to participate in computer planning at the departmental level came through involvement in a consultant study by Coopers and Lybrand Consulting Group. Participation in computer planning has continued through the development of a hierarchy of Management Information System (MIS) committees (Table 4).

There is a need for ongoing system development within the Department. This involves keeping up to date on the new equipment and software available, matching this with the expanding needs of users and developing linkages within and between divisions so that equipment, software and databases can be efficiently shared. These tasks are in addition to those of co-ordinating training, user support and application development within Divisions. Table 2 summarizes the changes that have occurred to date and those outlined in the Department's Long Range System Plan.

Table 4. Computer related committees - a hierarchical relationship is implied

COMMITTEE	FUNCTION
Electronic Data Processing Advisory Committee (EDPAC)	Interdepartmental Computer Committee
MIS Management Committee	Management Information Systems (MIS); Membership-MIS co-ordinator and Deputy Ministers
MIS Working Group	Recommends and implements 5 year plan; Membership-MIS management and divisional representatives
Training	Reviews training needs and organizes courses
Equipment	Reviews and processes equipment requests
Database	Co-ordinates development and integration of databases for departmental minicomputers

EDUCATION AND PUBLIC AWARENESS*

H. V. Donohoe and M. E. Devanney

The purpose of the Education and Public Awareness Program (EPAP) of the Mines and Minerals Branch is to develop educational information about the geology, mineral resources and mining history of the Province. The Canada - Nova Scotia Mineral Development Agreement (CNSMDA) plays an important role in the operation of the Program. Under the CNSMDA, the EPAP and the Public Information Program (PIP) share the objectives of building a broader understanding of mineral commodities, mining exploration, geology and mineral resources in Nova Scotia and of the government's role in promoting and managing them. These objectives are achieved through the publication of informative booklets, brochures and newsletters, travelling exhibits, a very popular series of guided walks, and the preparation and display of audio-visual packages.

A series of general information brochures now available include Nova Scotia Gold, Minerals and Mining in Nova Scotia and The Geology of the Halifax-Dartmouth Area. Brochures in the advanced stages of production are Coal in Nova Scotia and The Rock and Mineral Collecting Guide to Nova Scotia. In addition, a number of pamphlets dealing with regulatory issues have been produced, namely Mineral Rights, Landowners, and Mineral Exploration and Information on Staking Claims in Nova Scotia. The Directory of Goods and Services for Exploration Companies provides a convenient reference to companies serving Nova Scotia's exploration industry. Several longer publications near completion include Gold in Nova Scotia and Geology, Minerals and Mining in Nova Scotia.

During the summer of 1986, groups were guided on a walking tour of the building stones in downtown Halifax. The walk highlights the building stones and their constituent rocks and minerals as well as providing an insight into the historical development of the Province's building stone industry. The continued popularity of the building stone walk prompted the development of a guided walk to study the geology and landforms of Point Pleasant Park. This walk emphasizes how geological history influenced the settlement of Halifax. These co-operative projects, initiated by the Department and the Nova Scotia Museum, are funded under the CNSMDA.

Other collaborative NSDME - NS Museum projects include joint publications and the development of a mining loan kit available for use in the education system. The mining kit will include samples of rocks and minerals of economic importance, videos and an information package including brochures, posters, pictures and a teachers resource guide. The video presentations will depict a cross-section of commodities and mining methods representing different geographic regions of the Province. Preparation of these 'rock videos' began this fall with the filming of the underground salt mine at Pugwash, Cumberland County and the open-pit tin mine at East Kemptville, Yarmouth County. As well the Nova Scotia Department of Mines and Energy and the Nova Scotia Museum, with assistance from the Mining Society of Nova Scotia, Chamber of Mineral Resources, Department of Education and teachers are preparing an economic loan kit. This kit will complement the optional mining unit that is offered at the junior high school level. Targeting the kit at grade 8 students will allow some overlap of elementary and high school usage.

The EPAP maintained a busy display schedule during the summer erecting displays in locations throughout the Province (Table 1). These included a number of mall exhibits where displays could be introduced to a representative section of the general public.

Table 1. Summer display schedule-1986

DATES	LOCATION	EVENT
May 30, 31	Truro	K-Mart Mall display
June 13, 14, 15	Windsor	Nova Scotia Forestry Exhibition
June 20, 21	Sydney	Mayflower Mall display
June 25, 26, 27, 28	Ingonish	Ingonish Mining Society of Nova Scotia
July 4, 5	Halifax	Halifax Shopping Centre display
July 25, 26	New Glasgow	Aberdeen Mall display
August 8, 9, 10	Parrsboro	Rockhound Roundup
August 23, 24	Yarmouth	K-Mart Plaza display
September 5, 6	Bridgewater	Bridgewater Mall display
September 13, 14	Waverley	Waverley Gold Rush Days

The typical display format highlights the geology and mining industry of Nova Scotia and material related to the activities and programs of the CNSMDA. Samples of rocks and minerals native to the Province, including those of economic importance, are a popular part of the display, as are the give away samples accompanied by descriptions. Where applicable, displays include material of local interest. In Sydney, the importance of coal was highlighted, while in Yarmouth, a poster display centred on tin generated a great deal of interest. The focus of the display at the Rockhound Roundup in Parrsboro concentrated on some of the more interesting rock and mineral localities in the area, and the recent fossil-find. The gold panning demonstration at the Waverley Gold Rush Days was a great success. Personnel were available to answer questions and identify samples at all displays.

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*Funded by Nova Scotia Department of Mines and Energy under the Canada - Nova Scotia Mineral Development Agreement

The course Prospecting in Nova Scotia continues to be popular. Twenty-two people enrolled in the 1986 spring session at Dalhousie University, which was sponsored by the Nova Scotia Department of Mines and Energy, the Chamber of Mineral Resources of Nova Scotia and the Department of Geology at Dalhousie. An advanced propsecting course is in the planning stages.

With the support of the Public Information Program of the CNSMDA, projects are planned to prepare filmstrip presentations outlining the geology, mining and mineral resources of the Province, a continuing photographic record of exploration and mining developments, photographic packages related to the mining history of the Province, video documentaries on the geological history and mineral resources of Atlantic Canada, and newsletters. The intent of these projects is to reveal aspects of geology and mining normally seen and understood only by professionals.

LACUSTRINE DEPOSITS OF THE HORTON BLUFF FORMATION, HORTON GROUP, IN THE MINAS BASIN AREA

T. Martel* and M. Gibling*

ABSTRACT

The continental strata of the Lower Carboniferous Horton Bluff Formation were the first rocks deposited in the Minas Basin area following the Acadian Orogeny. The strata onlap the collisional suture between the Meguma and Avalon Zones (Africa/North America). Lithofacies variations in the Horton Bluff Formation are important as a key to the area's tectonic history. The formation's black shales and sandstones have economic potential as oil shale, petroleum source and reservoir rocks, and as a possible source of sulphide mineralization.

Current study of the Horton Bluff Formation has documented 450 m of lacustrine strata that show repeated shoaling-upward cycles. Each cycle, from base to top, is composed of an offshore lacustrine facies, a nearshore lacustrine facies, and a vegetated mudflat facies. The offshore lacustrine facies consists of uniform black shales, with minor oil shales and rare silt lenses near the top. In some sequences fish debris and arthropod shells are common at the base. The nearshore facies consists of interbeds of lenticular- and planar-bedded siltstone and sandstone with shale. Sedimentary structures include wave ripples, low-angle cross-stratification and various indicators of subareal exposure such as mudcracks, planed-off ripples, rooted horizons and amphibian footprints. Intensive synsedimentary deformation in the form of large subsidence hollows up to 15 m in diameter, as seen on bedding surfaces, and sandstone dykes occur especially at the transition zone between the nearshore and offshore facies. The vegetated mudflat facies consists of grey-green mudstone, generally with planar interbeds of siltstone. Plant bioturbation ranges from minor disturbance to well developed soil horizons. Plant fossils and impressions are common, as are duricrust horizons.

Cycles at the base of the sequence are 10 - 20 m thick and are dominated by the offshore lacustrine facies, whereas cycles at the top of the sequence are 3 - 5 m thick and are dominated by the nearshore facies.

Topics under investigation include: (a) organic production and preservation in the lacustrine setting (using maceral and organic carbon analysis); (b) shoreline processes in sand deposition and reservoir potential; (c) original fluid content and porosity changes during burial; (d) genesis of clastic dykes; (e) tectonic versus climatic control of cyclicity; and (f) relationship of sedimentation to the accretion of the Meguma basement to the North American craton.

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THE WESTPHALIAN B SPRINGHILL COALFIELD OF NOVA SCOTIA: PROCESSES OF COAL FORMATION AT AN ALLUVIAL BASIN MARGIN*

J. H. Calder

ABSTRACT

In the Westphalian B, 1380 m of alluvial coal-bearing strata within the Cumberland Group were deposited near the strike-slip fault margin of the southern Cumberland Basin. In this setting, coal (peat) swamps coexisted in close proximity to both basin margin and alluvial plain deposystems. The tectonic framework, patterns of basin fill, neighbouring geomorphic regions, and the ecology of the swamps all influenced coal (peat) deposition, in large part through their effect on groundwater distribution. A complex array of lithofacies was deposited as a result of the variety and spatial intimacy of the depositional systems adjacent to the coal (peat) swamps. Megascopic and microscopic aspects of the coals indicate a forest-moor coal facies. Each forest-moor swamp flourished in a 4.5-7 km wide zone of the alluvial plain (bajada), bordering distal alluvial fans derived from the Cobequid Highland to the south. Toward the basin center (northward), the swamps were bordered by the medial reaches of a trunk meandering river system. In the vicinity of the Springhill coalfield, this fluvial system was commonly oblique to parallel to the basin margin.

The location of the coal seams (peat swamps) was ultimately a function of the tectonic setting as well as the paleogeography of the basin. Alluvial fans, generated at the fault margin of the basin, provided a source of groundwater recharge which was crucial to the formation and preservation of the peat. With basin infilling, successively younger seams pursued this zone of recharge and progressively onlapped the distal fans while becoming increasingly restricted areally. Conditions conductive to swamp formation were further enhanced by a zone of maximum basin subsidence along a buried basement fault which underlies the coalfield.

The form of the coal seams was determined primarily by local geomorphology and deposystems bounding the swamps, although their elongate nature may have also been affected by the configuration of the groundwater recharge zone described above. The proximal (southern) margin of the forest swamps was defined by the topography and sporadic sheetflood discharge of the distal alluvial fans. The distal (northern) side of the swamps was profoundly influenced by the trunk river. Overbank deposition from the river occasionally interrupted peat formation, sometimes followed by meandering of the river over the distal swamp deposits. At such times, compaction of the underlying peat resulted in entrenchment and vertical aggradation of the fluvial system. The ultimate burial of the forest swamp was probably due to periodic avulsion of the trunk river. The interaction between the peat swamp and the bounding deposystems, manifested by modes of seam termination, gave rise to three distinct zones of coal (peat) deposition within each seam, here named by their position relative to the basin margin: (i) a proximal zone, which terminates toward the basin margin through lithification and splitting; (ii) a medial zone, largely unaffected by external fluvial processes; and (iii) a distal zone, which terminates toward the basin centre through splitting and subsequent thinning. The composition of the coals (lithotypes, ash and sulphur contents) varies laterally with these areal zones, and can be largely attributed to the effects of groundwater fluctuations and clastic input by the bounding deposystems. Preliminary attempts at recognizing lateral paleofloral variations within the swamp have proven inconclusive, however they are suggested within strata immediately overlying the coals.

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*Presented at International Symposium on Coal and Coal-Bearing Strata, Geological Society of London; Royal Holloway and Bedford New College, University of London, Egham Hill, Surrey, U. K., April 8-10, 1986

STRATIGRAPHY AND SEDIMENTOLOGY OF THE OIL SHALES AND ASSOCIATED CLASTICS OF THE STELLARTON GROUP, NOVA SCOTIA*

R. D. Naylor, G. A. Prime and W. D. Smith

ABSTRACT

Oil shale units of the east half of the Stellarton Basin occur within the grey coal-bearing members of the Westphalian B-C aged Stellarton Group. The upper three members of the Stellarton Group (Thorburn, Coal Brook and Albion) contain over 40 oil shale units. Individual units, some as thick as 50 metres, can be traced laterally 1-5 kilometres.

Oil shales are typically silicate-rich (quartz and clays) with humic and algal organic matter comprising up to 50 per cent (by weight) of the rock.

Lithologies interbedded with the oil shales include: 0.01 - 2 cm alternating siltstone and claystone couplets (F$_L$), siltstone with thin (1mm and less) parallel sandstone laminae (Fi), thinly interbedded flaser to lenticular siltstone and sandstone (Si), rippled sandstone (discontinuous-crested ripples, Sr$_1$; weakly undulatory to straight-crested ripples, Sr$_2$; bifurcating ripples, Sr$_3$), high angle trough cross-bedded sandstone (St$_1$), low angle trough cross-bedded sandstone (St$_2$), horizontal tabular-bedded sandstone (Sh), massive and cross-stratified pebble to cobble conglomerate (Gc), coal (C), cannel coal (Cc) and carbonaceous shale (Fc).

General depositional settings for the above lithologies include open lacustrine (oil shales, F$_L$), wave-influenced delta (Fi, Si), distributary and wave-influenced delta front (Sr$_1$, Sr$_2$, Sr$_3$ and St$_2$), fluvial channel and levee (St$_1$ and Fm), alluvial fan - fan delta (Gc and ?Sh) and well- and poorly-drained swamps (Fc, C and Cc). The restricted nature of the Stellarton Basin allowed for widespread abrupt transgressions and regressions of these depositional environments. As a result, further lithostratigraphic subdivision of the Thorburn, Coal Brook and Albion Members could prove difficult.

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*Paper presented at the Atlantic Geoscience Colloquium, January 17-18, 1986, Amherst, Nova Scotia

GYPSUM IN CANADA - PRESENT STATUS AND FUTURE DEVELOPMENTS*

J. H. Fowler and G. C. Adams

ABSTRACT

The gypsum industry in Canada began over two hundred years ago in the Maritime Provinces when farmers attempted to supplement their incomes by selling "land plaster" to traders bound for the United States. Rising from such humble beginnings, gypsum now contributes significantly to the economies of nine of Canada's ten provinces. Thirteen open-pit and three underground mines produced a total of 8.38 million tonnes of crude gypsum and seventeen processing plants manufactured 2.49 million tonnes of finished products in 1985. Recent economic growth in North America has resulted in steady increases in gypsum production, however competition from foreign producers and by-product gypsum poses a growing threat to Canada's gypsum mining industry.

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*Paper presented at the Society of Mining Engineers Annual Meeting, Denver, Colorado, February 1987

INDUSTRIAL MINERALS IN NOVA SCOTIA, 1985-86*

J. H. Fowler

ABSTRACT

Industrial mineral activities have increased in Nova Scotia as evidenced by production increases for several commodities and new interest in many of the Province's undeveloped resources. The current Canada - Nova Scotia Mineral Development Agreement, coinciding with this upswing, is providing funds at a most opportune time, allowing the Nova Scotia Department of Mines and Energy, and Energy, Mines and Resources Canada to undertake several industrial mineral programs designed to promote resource development in Nova Scotia. Programs underway include commodity market studies, mineral technology programs and mineral resource evaluation projects.

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*Presented at the Federal/Provincial Industrial Minerals Meeting in Ottawa, October 29-30, 1986

THE DEVELOPMENT POTENTIAL FOR NOVA SCOTIA'S OFFSHORE PLACER AND AGGREGATE RESOURCES*

C. K. Miller and J. H. Fowler

ABSTRACT

The prerequisites for the formation of placer gold deposits are met for offshore Nova Scotia, Canada. Auriferous bedrock was comminuted by glaciers and the resulting auriferous detritus was sorted and winnowed by fluvial and marine sedimentary processes.

The bedrock geology and surficial materials of the offshore are similar in composition to those onland, except for the modifying effects of the postglacial marine transgression that drowned most of the shelf area. Analogies can be drawn between the size and type of terrestrial placer gold deposits and auriferous detritus of the Province with deposits and detritus expected to occur offshore. Onland, no economic placer gold deposits have been discovered. The potential for sizeable offshore placer gold deposits will be dependent upon the thickness of rock comminuted by the glaciers, and the areal extent and efficiency of the secondary concentration systems. The most likely exploration targets are drowned pro- and post-glacial river channels, and auriferous glacial tills that lie very close to their bedrock source.

In addition to gold, tin, tungsten, ilmenite, garnet and zircon have placer potential offshore. Placer minerals may form important by-products to offshore aggregate operations.

Extensive, untapped sand, sand and gravel and gravel deposits have been mapped offshore Nova Scotia with large portions of these deposits occurring in water depths that would permit mining with established dredging technology.

The aggregate section of this paper presents the development history and current structure of the aggregate industry in Nova Scotia with emphasis on fixed aggregate markets in the major urban centres of the Province. As well, recent studies and developments which could trigger offshore aggregate production are discussed.

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NOVA SCOTIA FREESTONE: DIMENSIONS PAST, PRESENT AND FUTURE*

L. W. Batten** and G. B. Dickie

ABSTRACT

In the late 1800s up to 75 sandstone quarries produced stone for local and import markets. The largest volume of sandstone was raised at the Wallace Quarry, Cumberland County, with a total recorded production of just under 1 million tons. In 1985 the Nova Scotia Department of Mines and Energy initiated a 5 year project under the Canada - Nova Scotia Mineral Development Agreement to evaluate the building stone resources of Nova Scotia. This project will identify, test and compile promotional information on our building stone resources.

The South Western Stone Cleaning and Restoration Co. Ltd. was contracted to carry out the Province House restoration in 1985. As part of this project they have agreed to train 12 apprentices in the craft of stone masonry, thus providing a local group of people capable of using their new found skills for restoration projects in Canada and abroad. The Province House restoration became necessary because of the breakdown of the stone from which the building was constructed. Decomposition of the sandstone was aggravated by a number of factors including face bedded stone, application of render to the surface of the stone, salt contamination, water flowing over the surface of the stone and poor preventative maintenance over the last 150 years.

The future of the Nova Scotia stone industry is very bright. Markets for granite products such as cladding panels and curbing is rapidly growing. Nova Scotia granite may have the potential to gain a market share in this field. Nova Scotia sandstone has been used in building construction in many parts of Canada and the United States and may enjoy a level of increased demand as old structures are restored and new buildings designed.

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*Paper presented at the Annual Meeting, Mining Society of Nova Scotia, Ingonish, Nova Scotia, June 27, 1986

**President, Canstone Inc., St. 510 World Trade and Convention Centre, 1800 Argyle St., Halifax, Nova Scotia

NOVA SCOTIA MINERAL RESOURCES: OPPORTUNITIES FOR NEW INVESTMENT, NEW PRODUCTS AND NEW MARKETS, A PRELIMINARY REVIEW*

R. R. Potter

ABSTRACT

Nova Scotia has a well established and diversified mining industry, producing thirteen metals, minerals and commodities. In 1985 the value of minerals produced reached a record high of $325 million. More than 6000 people are directly employed by the Province's mining and mineral-based manufacturing industry. In 1985, the government of the Province of Nova Scotia identified the mineral industry as having considerable potential for increased investment to create new products and develop new markets. A review of all possible opportunities may form the basis for promoting these developments.

Coal, gypsum and salt have dominated Nova Scotia's mineral industry for several centuries, however other metals, minerals and mineral fuels may make a greater contribution in the near term. Included here are gold, tin, zinc, copper, strontium, barite, petroleum-gas, aggregates and building stone. Nova Scotia is strategically located to compete in a "shrinking globe" with abundant resources. Its all-weather, deep-water ports and well established road and rail facilities will enable high bulk, low unit value minerals such as gypsum, limestone, dolomite and aggregates to be transported competitively to national and international markets. Many of Nova Scotia's minerals may also be used in conjunction with other raw materials produced in the region. They could form the basis for the production of a variety of agricultural or industrial chemicals. Investment opportunities may also exist for gold and silver, for ferrous metals such as manganese, vanadium and cobalt, for catalysts such as lithium and rhenium, for light construction metals, and for a number of minor metals used in the electronics industries. Industrial minerals are also becoming increasingly important, including those that are used in the metallurgical, agricultural, chemical, pulp and paper and ceramic industries. Also, rocks, minerals and aggregates utilized in the construction industry should have a bright future in the export trade because of the Province's location on tide water. The Province has many basic mineral resources that are required for the production of fillers, extenders, adsorbents and filters. They may also form the basis of further investment and the development of new products.

Nova Scotia has extensive coal reserves, well located for increased production, expanded markets and new products. With the existing coal production and offshore gas and oil potential, the Province is in a good position to develop smelting, refining, industrial chemical or other mineral-based manufacturing opportunities.

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*Presented at the Annual Meeting of the Nova Scotia Mining Society, June 26, 1986, Ingonish, Nova Scotia

NEW PERSPECTIVES ON GRANITE-RELATED MINERAL DEPOSITS IN SOUTHERN NOVA SCOTIA*

P. S. Giles and A. K. Chatterjee

The past ten years in Nova Scotia have been most productive in terms of mineral exploration efforts and concurrent studies of granite petrogenesis and metallogenesis leading to important discoveries of granite-related mineral deposits, the most significant of which is Rio Algom's East Kemptville tin (copper-zinc-silver) deposit. The East Kemptville mine will produce approximately 4500 tonnes of tin-in-concentrate annually over the next twenty years, representing two per cent of 1984 world tin production. This internationally significant deposit represents the first of its kind in the extensive granitic terrane of southwestern Nova Scotia and the first primary tin deposit in North America. In addition, new occurrences of uranium and tungsten have been found in this environment.

Table 1 summarizes the chronology of parallel developments in mineral exploration and geological research in southern Nova Scotia. These efforts have been concentrated on peraluminous Devonian granitoid rocks of the South Mountain Batholith (S), Musquodoboit Batholith (M) and, most recently, the Liscomb Pluton (L) (Fig. 1A). Granophile mineralization associated with these granitoids is both intrabatholithic and peribatholithic in character.

The Tobeatic Fault Zone (Fig. 1A) extends from the Yarmouth-Wedgeport area of southwestern Nova Scotia, northeasterly through the New Ross-Vaughan district to merge with mapped faults cutting latest Visean strata in the major Carboniferous basins of southern Nova Scotia. This zone is indicated at intervals along its trace by linear zones of variably intense shear cutting the granitoids of the South Mountain Batholith.

Offset of major Carboniferous and older structural features, and displacement of Carboniferous facies belts suggest post-Visean sinistral displacement of approximately 110 km on the Tobeatic Fault Zone. Mineral ages and whole-rock isochrons indicate plutonism and mineralization of Late Carboniferous age in southern Nova Scotia. Both temporal and spatial links with this major shear zone can be demonstrated and emphasize its possible relevance to the search for granite-related mineral deposits.

Reconstruction involving removal of approximately 110 km of postulated sinistral movement on the Tobeatic Fault Zone in southern Nova Scotia, reduces the South Mountain and Musquodoboit Batholiths, and the Liscomb Pluton to a single composite granitoid complex (S-M-L) of elliptical configuration (Fig. 1C) approximately 180 km by 120 km in dimension. This suggests a common petrogenetic history and possibly a shared mineral potential for these granitoid rocks.

The S-M-L reconstruction (1) resolves the enigmatic banana-shape of the South Mountain Batholith by making it a part of a larger subcircular plutonic complex, including the Musquodoboit Batholith and the Liscomb Pluton, which is more comparable in configuration to other large batholithic complexes; (2) merges regional negative Bouguer gravity anomalies (see Fig. 1B); (3) explains the presence and orientation of steep gravity gradients within parts of the South Mountain Batholith; (4) merges regional airborne radiometric highs centred in the vicinity of New Ross and Davis Lake; (5) provides, through the shear mechanism invoked, an explanation for the localization and contrasting character in time and space of the leucocratic granitoids in relation to mineralization; (6) rationalizes the distribution of granophile metallogenic domains which are proximal to the sinistral fault zone in southwestern Nova Scotia, and thereby offering possibilities for future exploration models; (7) explains, with the shear mechanism as a localizing agent, temporal and spatial distinction of radiogenic leads of granitoid affinity from Meguma-derived lead; (8) predicts and explains the presence of megacrystic granodiorite, similar to that of the South Mountain Batholith, in the Liscomb Pluton; and (9) forecasts local negative Bouguer gravity anomalies as indicators of cupolas hidden beneath a veneer of Meguma Group rocks or previously crystallized granitoid rocks, or both, and thus outlining possible buried targets for mineral exploration.

The apparent genetic and spatial links of granophile mineral deposits to the Tobeatic Fault Zone provide an immediate focus for mineral exploration and an important new hypothesis on the mineral potential of the granitoid rocks of southern Nova Scotia. This conceptual modelling exercise should provoke pragmatic exploration considerations. The ongoing Nova Scotia experience illustrates the benefits accruing from concurrent and co-operative research and mineral exploration.

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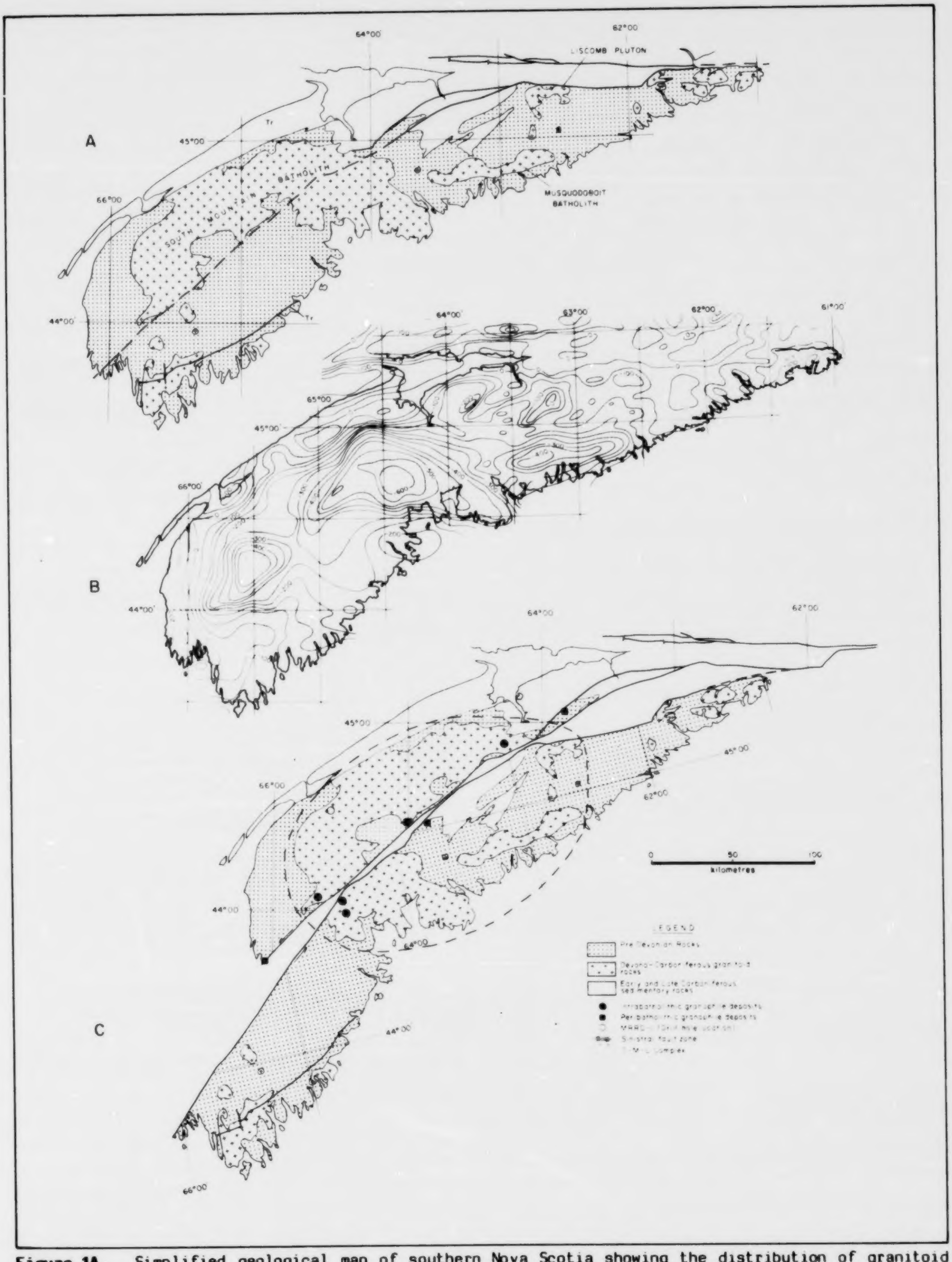
*Presented at Prospectors and Developers Association Annual Meeting, March 1986, Toronto, Ontario

Table 1. Sequence of signifcant developments in mineral exploration, petrogenesis and metallogenesis in granitoid rocks of southern Nova Scotia.

YEAR	TOPIC	REFERENCE*	REMARKS
1974-1980	- petrology and geochemistry	McKenzie and Clarke, 1975 Clarke et al., 1976 Smith and Turek, 1976 Chatterjee, 1980 Clarke and Halliday, 1980 Longstaffe et al., 1980	Documentation of the differentiated nature (granodiorite to porphyry) of the SMB; documentation of peraluminous minerals; e.g. andalusite, garnet, etc., as magmatic minerals; oxygen and strontium isotopic evidence for origin of SMB; style and variety of mineralization in SMB.
	- regional compilation	Keppie, 1979	Compilation of previous mapping
1981-1985	- isotopic dating - regional metallogeny - role of leucogranites as metal generators - hydrothermal alteration of the granitoid rocks - similarity in metallogenic evolution between the Appalachians and Hercynian Europe	Muecke and Clarke, 1981	Constraints on geochemical evolution of SMB, REE evidence
		Reynolds et al., 1981	$^{40}Ar/^{39}Ar$ geochronology of granitoid rocks, geological evolution of the Meguma Zone
		Chatterjee et al., 1982	Documentation and hydrothermal alteration attending U mineralization, Millet Brook deposit
		Chatterjee and Muecke, 1982	Radioelement distribution and exploration implications in the SMB
		O'Reilly et al., 1982	Style of mineralization and origin of deposits in the New Ross area, SMB
		Chatterjee, 1983	Delineation of metallogenic domains, SMB and immediate environment
		Chatterjee et al, 1983	Contrasting leucogranites related to mineralization, the role of fluids
		Chatterjee and Strong, 1984a	Description and geochemistry of the East Kemptville Deposit
		Chatterjee and Strong, 1984b	Hydrothermal alteration of granitoid rocks, Millet Brook deposit
		Chatterjee and Strong, 1985	Geochemical characteristics of the tin domain
		Clarke and Chatterjee, 1985	Documentation of magmatic and post-magmatic processes
		Clarke and Muecke, 1985	Overview of petrology and geochemistry of SMB
		Clarke et al., 1985	Sm-Nd study of SMB and Cambro-Ordovician metasedimentary rocks
	- petrology and geochemistry of the Musquodoboit Batholith	MacDonald and Clarke, 1985	First database on Musquodoboit Batholith with assessment of mineral potential
		Maillet and Clarke, 1985	Role of cordierite as a magmatic mineral in peraluminous granitoids.
	- new perspectives	Giles, 1985	Documentation and implications of major fault displacement of southern Nova Scotia granitoids
	- current programs, Nova Scotia Department of Mines and Energy	NSDME staff	Systematic mapping (1:50,000) of the South Mountain Batholith with concurrent surficial mapping and studies of till mineralogy and geochemistry. Deep drilling of granitoid rocks as part of Mineral Resources Research Drilling Program
1976-1985	- discoveries and exploration	Open Files, Nova Scotia Department of Mines and Energy	Pre 1974 - total of 7 drill holes in SMB 1974-1982 - more than 200 drill holes completed 1976 - discovery of tin in southwestern Nova Scotia by Cuvier Mines Ltd. 1977 - active exploration by Shell Minerals Inc., tin discovered in veins in Cambro-Ordovician metasediments 1977-1978 - uranium discovered in SMB by ESSO Minerals; active exploration at East Dalhousie depicting U mineralization similar to that in Massif Central. 1977-1978 - active exploration, Aquitaine discovery of Millet Brook deposit 1978 - exploration with uranium emphasis, Shell minerals 1979 - till geochemistry leads to East Kemptville tin 1983-1985 - active exploration in Musquodoboit Batholith by Billiton and Kidd Creek, discovery of significant tungsten mineralization

*References not cited in abstract to conserve space; not intended to be a complete reference source.


A
LISCOMB PLUTON
64°00'
62°00'
45°00'
66°00'
44°00'
SOUTH MOUNTAIN BATHOLITH
MUSQUODOBOIT BATHOLITH
Tr
B
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45°00'
66°00'
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C
64°00'
62°00'
45°00'
66°00'
44°00'
0
50
100
kilometres
LEGEND
Pre-Devonian Rocks
Devono-Carboniferous granitoid rocks
Early and Late Carboniferous sedimentary rocks
Intrabatholithic granophile deposits
Peribatholithic granophile deposits
MARC-1 (Drill hole location)
Sinistral fault zone
S-M-L complex

Figure 1A. Simplified geological map of southern Nova Scotia showing the distribution of granitoid rocks and the postulated fault zone (TFZ) which dislocates the S-M-L complex.

Figure 1B. Regional Bouguer gravity, southern Nova Scotia.

Figure 1C. Reconstruction of the S-M-L complex, the fault zone, and documented significant mineral deposits.

ISOTOPIC STUDIES OF GRANITES AND ASSOCIATED MINERAL DEPOSITS OF NEWFOUNDLAND AND NOVA SCOTIA*

A. K. Chatterjee and D. F. Strong**

Strontium isotope data for granitoid rocks of Newfoundland are irregular in distribution, values and quality. There is a tendency for increasing initial ratios with time, suggesting their derivation from crustal sources with increasing Rb/Sr ratios, and there could be some grouping with respect to terrane boundaries. However, very few of the data have been confirmed by other isotopic techniques, and caution is essential in their interpretation. Isotope data for granite-related mineral deposits are even scarcer, but they do give some indication of the sources for metals and fluids.

Plots of $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ show that galena from the Millet Brook U-Cu-Ag deposit is least radiogenic whereas that from the Grey River tungsten deposit is most radiogenic, and the data define a field enclosing the East Kemptville Sn-Cu-Zn-Ag, Dunbrack Pb-Ag-P, and St. Lawrence F, which we term the Appalachian granite envelope. This range is very similar to that defined for feldspars from Hercynian granitoid plutons in the Iberian Peninsula. The Dunbrack and St. Lawrence lead isotopic compositions closely agree with those for feldspar lead obtained of Appalachian late orogenic plutons from New Hampshire to South Carolina and Georgia. These observations suggest a common source for the granites and the mineral deposits, and also the nature of the basement source(s) for radiogenic lead incorporated in the plutons. The galena from Millet Brook granodiorite (South Mountain Batholith) is assumed to represent lead from such a common source. Three samples representing Sn-W mineralization near Goose Lake (peribatholithic mineralization related to Wedgeport Pluton) fall outside the Appalachian granite envelope, probably representing a mixture of lead from the Meguma Group and from Carboniferous Wedgeport Pluton. The range of $^{206}Pb/^{204}Pb$ in galena from the other peribatholithic deposits is almost identical to that represented by Nova Scotian granitoid rocks. The compositions of lead from the intra- and peribatholithic environments hosting granophile mineralization agree closely with the 'orogene' evolution curve, suggesting that they have been derived from homogenized continental crust.

Oxygen isotope data could suggest that the Meguma Group could have been the source rock for the South Mountain Batholith (SMB), but $^{87}Sr/^{86}Sr$, $^{34}S/^{32}S$, and $^{143}Nd/^{144}Nd$ isotopic data, together with the REE data, do not fully support this view. The whole-rock $\delta^{18}O$ values for various types of polymetallic tin and uranium mineralization show a positive correlation between U/Th ratios and $\delta^{18}O$ values in comagmatic granodiorite-monzogranite-aplite. However, granitoid rocks from the Davis Lake complex, Wedgeport Pluton, and associated greisens do not fall within the range of $\delta^{18}O$ values defined for the SMB. More important however, is an increase in U/Th with little or no change in $\delta^{18}O$ values, clearly demonstrating that the quartz-topaz greisen at East Kemptville has evolved from the granites without significant incorporation of different $\delta^{18}O$ values. This is in agreement with the trace element data where it was demonstrated that the greisen at East Kemptville resulted essentially from a magmatic-hydrothermal process, which gave rise to continuous transition from granite to greisen.

The intrabatholithic quartz-muscovite greisen associated with the Wedgeport Pluton and the peribatholithic mineralization characterized by intense chloritization in the Meguma metasediments, essentially show similar trends and a wide range in $\delta^{18}O$ values, probably due to mixing of meteoric water with hydrothermal fluids. Peribatholithic muscovite- and fluorite-rich sulphide veins in the metasediments show a significant departure from the above trends and in general are similar to the Davis Lake-East Kemptville trend.

The $\delta^{18}O$ values for granitoid rocks hosting uranium mineralization in the SMB are anomalously high and are correlated positively with U/Th ratios, likely due to mixing of magmatic and metamorphic fluids ultimately derived from sediments or other sources already enriched in U, which in turn may have regional implications for source regions. The mineralized granitoid rocks show a range in whole-rock $\delta^{18}O$ values between 12.3 and 15.3 o/oo, representing a positive shift of approximately 4.44 o/oo from unaltered rocks. Other uranium deposits within the SMB show similar positive correlation between U/Th ratio of the rock and whole-rock $\delta^{18}O$ values, although each deposit defines a slightly different slope.

Oxygen isotope data are not abundant for granite-related deposits of Newfoundland, but those available for the St. Lawrence fluorite veins and the Ackley Mo and Sn mineralization indicate magmatic origins for both. This is consistent with all of the isotopic data reviewed above, and if it is a valid generalization that all Appalachian granite-related mineral deposits are magmatically derived, then it follows that they are likewise controlled by the source regions for the magmas. There is clearly a need for many more detailed studies of both stable and radiogenic isotopes in these systems, with implications ranging from metallogeny and petrogenesis to crustal evolution.

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*Also in Program with Abstracts; Newfoundland Section, Geological Association of Canada, Annual Spring Meeting, Memorial University of Newfoundland, St. John's, March 20-21, 1986, p. 15-16.

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EVOLUTION OF THE LISCOMB COMPLEX AND ITS RELEVANCE TO METALLOGENY IN THE EASTERN MEGUMA ZONE*

P. S. Giles and A. K. Chatterjee

ABSTRACT

The western half of the Liscomb Complex in southern Nova Scotia consists of (i) granitic rocks ranging in composition from biotite granodiorite to 2-mica leucomonzogranite, (ii) a metamorphic rock suite ranging in composition from mafic to quartzo-feldspathic gneisses, and (iii) two mafic diatremes/breccia pipes characterized by a volatile-rich matrix. Field relationships suggest that the entire complex is intrusive into the deformed and metamorphosed Cambro-Ordovician Meguma Group. Thus, the complex is post-tectonic. The inferred diapiric mechanism of intrusion implies rapid uplift and emplacement in a time frame bracketed by Acadian metamorphism (415-400 Ma) and granitoid intrusion (370 Ma) in the Meguma Zone.

The granitic rocks are peraluminous (A/CNK 1.14-1.35). Silica variation diagrams involving most major and trace elements are systematic and are suggestive of magmatic differentiation controlled to a large extent by fractional crystallization of feldspar, biotite and Fe-Ti oxides. Elemental ratios such as Th/U, Ti/Zr and Zr/Y suggest that (i) each pluton had its own crystallization history and (ii) the trace element characteristics were largely controlled by source rock composition, degree of partial melting and other factors.

The high-grade metamorphic suite contains characteristic minerals such as orthopyroxene, clinopyroxene, garnets, hornblende and Al-silicates in rocks of appropriate composition suggestive of granulite facies conditions. However, overgrowth of minerals and disequilibrium textures are common, suggestive of amphibolite facies conditions. Geochemically the gneisses show the largest variation in SiO_2 content of the three major rock suites within the complex and variation diagrams are characteristic of igneous suites. Geochemically the high-grade gneisses are unlike Meguma metasediments. We suggest that the protolith may have been a mixed volcano-sedimentary sequence.

The diatremes/breccia pipes contain a wide assortment of xenoliths and large rafts of mafic igneous rocks. The matrix of the breccia pipes ranges in composition from quartz-gabbro to quartz-diorite and contains abundant sulphides (Py-Po-Cp). The mafic rocks include plagioclase-free rocks dominated by pyroxenes, rocks containing kyanite with overgrowth of sillimanite and rocks containing abundant garnets. Fractional crystallization involving olivine, pyroxene and plagioclase explains the major and trace element geochemistry.

The Liscomb Complex apparently evolved through diapiric emplacement of high-grade gneisses, driven by heat from mafic bodies which subsequently rose rapidly following pre-heated conduits and intruded their gneissic shell. Volatiles in the mafic diatremes explain their anomalous buoyancy. Granitoid intrusion completed the sequence of events, perhaps representing the culmination of an essentially continuous intrusive process.

A strong NNW trending magnetic linear cross-cuts the Liscomb Complex near its western margin, and may represent a deep crustal structure of significance to the metallogeny of the complex and to its geological evolution. The trend of this linear is diametrically opposed to the northeasterly magnetic grain of the Meguma Zone.

Metallogenetically, the leucogranites are enriched in some of the granophile elements when compared to the average granite. Gold values in granitic rocks range from 2 ppb to 22 ppb, in high-grade gneisses from 9 ppb to 87 ppb and in mafic rocks from 7 ppb to 38 ppb. Although gold mineralization is not known in the Liscomb Complex, similar geological settings in the Bonnac district of the Massif Central host a number of mines (Au, Sb) and prospects in high-grade gneisses of presumably similar age. This similarity further enhances the metallogenic analogy between the Meguma Zone and Hercynian Europe and suggests new environments for mineral exploration in southeastern Nova Scotia.

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*Presented at CIM District 1 Meeting, November 1986, Halifax, Nova Scotia

SALT AND POTASH RESOURCES IN NOVA SCOTIA*

R. C. Boehner

ABSTRACT

The salt and potash resources of Nova Scotia are described from all available geological, geophysical and geochemical data. Twenty-three deposits and thirteen occurrences are known with subeconomic potash (sylvite and carnallite) associated with thirteen of the salt deposits in the Middle to Late Visean (Early Carboniferous) Windsor Group. Minor evaporites, including halite, are locally present in the underlying Horton Group but no potentially exploitable deposits are known.

The Windsor Group (Visean) is a regionally widespread unit up to 1000 metres thick. It is dominated by subaqueous and diagenetic marine evaporites, including halite, anhydrite, gypsum and potash, with subordinate interstratified redbeds and marine carbonates. These rocks display a wide range of structural and stratigraphic complexities within the Carboniferous depositional and tectonic setting. Carboniferous basins in Nova Scotia are part of the complex Magdalen (Fundy) Basin system developed in the Acadian Orogen in Atlantic Canada. They contain up to 7000 metres of pull-apart basin molassic sediments with minor, but economically important, marine evaporites of the Windsor Group. Deformation varies from negligible in the relatively stable platform blocks characterized by thin sediment accumulation, to substantial deformation in the fragmented basinal areas involving Hercynian strike slip, thrust and normal faulting, gravity sliding, evaporite diapirism and folding of the thick sedimentary fill.

Until recently, the distribution and geology of the evaporites, especially salt and potash, have been poorly understood because of limited data. Recent drilling has established that salt is present throughout the Windsor Group section. The principal salt unit including potash (sylvite and carnallite) is located in a major carbonate-sulphate-chloride cycle at the base of the Windsor Group. Thinner and younger salt beds with minor potash are locally present in association with anhydrite and marine carbonate in numerous saline minicycles.

The major salt producers in Nova Scotia are a conventional underground mine at Pugwash operated by The Canadian Salt Company Limited and a brining mine at Nappan operated by Domtar Incorporated, Sifto Salt Division. Nova Scotia has large salt resources and some potash. It is located near potential markets and along major shipping routes. These factors should enhance further development of mining, chemical and underground storage industries in the Province.

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*Also in Salt and Potash Resources in Nova Scotia; Nova Scotia Department of Mines and Energy, Bulletin No. 5, 1986, 346 p.

WINDSOR GROUP SALT AND POTASH IN NOVA SCOTIA, CANADA*

R. C. Boehner

ABSTRACT

The Windsor Group (Visean) is a regionally widespread unit up to 1000 m thick. It is dominated by subaqueous and diagenetic marine evaporites including halite, anhydrite, gypsum and potash with subordinate interstratified redbeds and marine carbonates. These rocks display a wide range of structural and stratigraphic complexities within the Carboniferous depositional and tectonic setting. Carboniferous basins in Nova Scotia are part of the complex Magdalen (Fundy) Basin system developed in the Acadian Orogen in Atlantic Canada. They contain up to 7000 m of pull-apart basin molassic sediments with minor, but economically important, marine evaporities of the Windsor Group. Deformation varies from negligible in the relatively stable platform blocks characterized by thin sediment accumulation to substantial in the fragmented basinal areas involving Hercynian strike slip, thrust and normal faulting, gravity sliding, evaporite diapirism and folding of the thick sedimentary fill.

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The large salt resources of Nova Scotia, together with geographic location and the presence of potash, are important factors which may encourage future development of mining and chemical industries and underground storage facilities.

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*Also in Sixth International Symposium on Salt, Toronto, 1983; 1985, The Salt Intitute, Virginia, U.S.A., v. 1, p. 99-113.

STRATIGRAPHY AND DEPOSITIONAL HISTORY OF MARINE EVAPORITES IN THE WINDSOR GROUP, SHUBENACADIE AND MUSQUODOBOIT STRUCTURAL BASINS, NOVA SCOTIA, CANADA*

R. C. Boehner

ABSTRACT

The Windsor Group contains a major proportion of evaporite rocks including anhydrite, gypsum, and halite. Three major depositional cycles are recognized. The lower cycle, dominated by restricted hypersaline subaqueous marine evaporite deposition in a preformed basin, is characterized by a thin basal dolostone overlain by a thick massive anhydrite and halite with thin anhydrite and siltstone interbeds. In marginal areas, the anhydrite locally intertongues with terrigenous sediments. Basinward, precipitation of anhydrite preceded halite which accumulated in a shrinking basin above and adjacent to anhydrite being subaerially exposed due to evaporative drawdown. The more complex middle and upper cycles contain repeated minor cycles of laterally extensive transgressive-regressive marine carbonates and terrigenous siliciclastic rocks with a variable, but generally large, proportion of evaporite including anhydrite and minor halite. Anhydrite occurs as nodules in siltstone or carbonate, which grade to coalescing nodular mosaic masses. The anhydrite associated with the halite is massive to locally laminated and halitic. Nodular anhydrite, both in situ and as transportated clasts, had a diagenetic sabkha-type origin in low-relief prograding coastal mud flats. The massive to laminated anhydrite, with or without stratified or herringbone crystalline halite, was precipitated in hypersaline shallow pans and coastal lagoons. Thick evaporites of the lower cycle progressively infilled the initial basin and effectively leveled topographic irregularities. The resulting surface of low relief and gentle slope favoured shallow water and diagenetic evaporite deposition throughout the two subsequent cycles. Depositional trends indicate increased evaporite thickness toward the northwest, with a maximum in the Shubenacadie Basin, and thinner, more localized evaporite deposits in the younger beds.

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*Also in Ninth International Congress of Carboniferous Stratigraphy and Geology, Urbana, Illinois, 1979; 1984 Compte Rendu, v. 3, p. 163-178.

CARBONIFEROUS-JURASSIC SEDIMENTATION AND TECTONICS: MINAS CUMBERLAND AND MONCTON BASINS, NOVA SCOTIA AND NEW BRUNSWICK*

R. C. Boehner, J. H. Calder, D. C. Carter,
H. V. Donohoe, Jr., L. Ferguson**, R. K. Pickerill***
and R. J. Ryan

ABSTRACT

Numerous conflicting and diverse interpretations have been advanced for the sedimentary and tectonic history of Late Paleozoic - Early Mesozoic basins in the northern part of the Appalachian Mountains. The field trip will examine a broad range of post-Acadian sedimentation and structural styles across the southwest end of the regional Maritimes Basin - Fundy Rift. The varied environments include active and passive basin margins, large fault zones, evaporite diapirs, continental redbeds, alluvial fanglomerates, alluvial coal basins, oil shales and fluvial lacustrine deposits, marine evaporites and aeolian clastics, as well as volcanic rocks. This overview of the highly complex geology illustrates many aspects of the interrelationships between sedimentation and tectonic history.

Late Paleozoic deposition of mainly continental strata with minor volcanism followed the Acadian Orogeny in a transpressive environment. The basin complex contains an Early - Late Devonian-Namurian rift molassic phase (areally restricted) which was followed by a later widespread (Westphalian-Permian) foreland basin phase. This pattern is controlled and complicated by a tectonic pulse (Hercynian-Variscan?) in the middle part of the Carboniferous and by syn- and post-depositional fault motion, deformation and evaporite diapirism.

Early Mesozoic deposition is confined to the Fundy Rift which is a narrow highly complicated fault zone (Minas Geofracture) through central Nova Scotia and extending into the Bay of Fundy. This rift-graben deposition dominated by continental redbeds with local volcanism resulted from the initial stages of the opening of the Proto-Atlantic ocean.

Because of the broad nature of the topic, no attempt is made to provide a comprehensive evaluation of the existing models. Participants, however, will be exposed to wide ranging geological environments and differing views.

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*Also in Basins of Eastern Canada and Worldwide Analogues, Symposium Field Trip; Atlantic Geoscience Society, Special Publication Number 4, 1986, Halifax, Nova Scotia, 122 p.

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FOSSIL MYRIAPOD TRAILS IN THE PERMO-CARBONIFEROUS STRATA OF NORTHERN NOVA SCOTIA, CANADA*

R. J. Ryan

ABSTRACT

Several new localities of the trace fossil, Diplichnites have been found in the Permo-Carboniferous strata of northern Nova Scotia. The trails at Cape John, Nova Scotia are the largest and the youngest record of this genus attributed to myriapods recorded to date. The Smith Point locality is noteworthy because of the number, preservation and turning configurations of the trails. Poorly preserved trails are also found near Pugwash, Cumberland County, Nova Scotia. These trails are attributed to the giant Carboniferous myriapod, Arthropleura.

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*Also in Maritime Sediments and Atlantic Geology, 1986, v. 22, no. 2, p. 156-161.

UPPER PALEOZOIC SEDIMENTATION AND BASIN DEVELOPMENT ADJACENT TO THE COBEQUID HIGHLANDS MASSIF, EASTERN CANADA*

R. J. Ryan, J. H. Calder, H. V. Donohoe, Jr. and R. D. Naylor

ABSTRACT

The northern part of the Minas Sub-basin and the Cumberland Basin of northern Nova Scotia and southeastern New Brunswick are adjacent to the Cobequid Highlands Massif. The Minas Sub-basin occupies an area south of the Cobequid Highlands Massif in part within the suture zone between the Avalon Composite Terrane and the Meguma Terrane. Movement on the suture zone resulted in a thick (5 km) succession of Middle Devonian to Lower Permian strata primarily of continental origin. The Cumberland Basin is a large Carboniferous structural basin which contains over 7 km of dominantly continental clastic strata with one major evaporitic marine succession. There are three allocycles within the Middle Devonian to Lower Permian strata of the Cumberland Basin and the northern part of the Minas Sub-basin. These are the Mid-Devonian to Namurian, the Namurian to Westphalian A and the Westphalian B to Early Permian. Within the northern part of the Minas Sub-basin the Fundy Rift resulted in the deposition of Triassic-Jurassic strata which record another allocycle.

Each of the megasequences records a decelerating subsidence rate. An initial period of uplift of the highlands and rapid subsidence of the adjacent basin resulted in the deposition of coarse fanglomerates locally at the basin margins. These coarse marginal deposits are succeeded by a transition to fluvial, lacustrine and, in one case, marine basin fill of widespread extent which may overstep the older basin fill units and the basement rocks. The distribution of marginal alluvial fan deposits indicate that the Cobequid Highlands Massif was a fault-bounded wedge which tilted in different orientations through time in response to strike-slip movement along the faults.

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*Also in Canadian Society of Petroleum Geologists, Special Memoir No. 12, in press.

GEOLOGY, GEOCHEMISTRY AND EXPLORATION APPLICATIONS FOR THE PERMO-CARBONIFEROUS STRATABOUND SEDIMENT HOSTED COPPER DEPOSITS OF THE CUMBERLAND BASIN, NORTHERN NOVA SCOTIA, CANADA*

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ABSTRACT

The Cumberland Basin is a large (3600 km^2) Carboniferous basin in northwestern Nova Scotia and southeastern New Brunswick, Canada. The most numerous mineral occurrences are the Cu-Ag Nacimiento type associated with the reddened continental sandstones and shales of the Pictou Group (Late Carboniferous to Early Permian). The Cu mineralization occurs as chalcocite with pyrite and bornite near the red to grey boundaries within the strata. The depth (up to 440 m) of the mineralization suggests it is not shallow supergene (<20 m) as previously proposed.

The colouration of the redbeds is secondary (diagenetic) and the till, stream sediment and lithogeochemistry indicate Cu has been depleted from the redbeds, probably at the time of reddening. It is proposed that oxygenated ground water carried the Cu in solution from the redbeds to sites of reducing conditions, either carbon-rich lags within the channel sandstones or at the interface with saline basinal waters, where the Cu was precipitated as a solution front.

The association of extensive areas of low Cu geochemical values (negative anomalies) with redbeds containing numerous Cu occurrences, delineates potential areas of exploration for mineralization of this type. The common association of Ag and Au with these occurrences enhances their attractiveness as exploration targets.

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THE LATE PRECAMBRIAN ANTIGONISH TERRANE (A PERIARC BASIN) UNCONFORMABLY OVERLAIN BY PALEOZOIC OVERSTEP ROCKS TYPICAL OF THE AVALON COMPOSITE TERRANE, NEAR ANTIGONISH, NOVA SCOTIA*

J. B. Murphy** and J. D. Keppie

The Late Precambrian Antigonish Terrane is an oceanic, deep marine sequence of rocks interpreted to have been deposited in a periarc basin. This terrane contrasts with other Late Precambrian terranes in the Avalon Composite Terrane, which are generally composed of either bimodal continental volcanic rocks or cratonic volcanic arc sequences (Keppie, 1982a, b, 1985). On the other hand, the Cambrian and Silurian rocks in the Antigonish Highlands are very similar to correlative units occurring elsewere in the Avalon Composite Terrane, suggesting that the distinct Late Precambrian terranes were amalgamated by the end of the Precambrian.

The Late Precambrian rocks of the northern Antigonish Highlands have been mapped as the Georgeville Group (Murphy and others, 1982; in press) which has been subdivided into several formations. Of these, three occur in the coastal fault block where the lowest unit exposed is the Chisholm Brook Formation. The base of this formation is not exposed. It consists of interlayered, ocean-floor, tholeiitic mafic flows, tuff, marble and mudstone in the west, the mafic flows and tuff pervasively intruded by dikes in the east. The overlying Morar Brook Formation is mainly composed of finely laminated, black porcelaneous mudstone with thin siltstone and chert horizons and rare thin limestone and conglomerate beds. Cross bedding, graded bedding and slump structures are present in these beds. The contact between the Morar Brook and Chisholm Brook Formations is gradational, with the boundary placed at the top of the highest volcanic unit. These rocks are overlain conformably by the Livingstone Cove Formation containing conglomerates interbedded with black mudstones and siltstones. The conglomerate horizons commonly have channeled bases and the clasts are generally supported by a sandy volcaniclastic matrix exhibiting both normal and reverse grading. Pebbles in the conglomerates are predominantly of volcanic origin with some granite and others of locally derived black mudstone. The base of the Livingstone Cove Formation is placed where conglomerate enters the section. The top of the Livingstone Cove Formation is truncated by the angular unconformity at the base of the Middle Devonian McAras Brook Formation.

The environment of deposition of the Georgeville Group is inferred to have been a quiet deep water basinal area into which volcaniclastic deposits entered in turbidity currents with detritus supplied by erosion of rapidly rising volcanic highlands. The marble horizons within the group are thought to have been deposited in shallow seas fringing volcanic islands.

During the Late Precambrian Cadomian Orogeny, the Georgeville Group was deformed first by thrust faults and NNW-SSE trending tight to isoclinal, recumbent, westerly vergent folds with a weak axial planar cleavage defined by chlorite, sericite and minor biotite. This was followed by refolding about NE-SW and E-W upright folds. F_1 was accompanied by greenschist facies metamorphism. The deformation was followed by sporadic plutonism, exemplified in the coastal fault block by the post-tectonic gabbroic Greendale Complex and alaskite. 40Ar/39Ar incremental release data on large metasomatic hornblende crystals from this gabbro display a disturbed spectrum with ages ranging from 653 ± 8 to 599 ± 9 Ma. This age suggests that the gabbro is Late Precambrian and the disturbance noted in the spectrum is inferred to be due to the subsolidus metasomatism recorded by Murphy (1982). The alaskite has been dated by Cormier (personal communication, 1982) using Rb-Sr on whole rocks at 535 ± 13 Ma (initial 87Sr/86Sr ratio = 0.765 ± 0.03). However, a K-Ar age on muscovite (%K=7.83) from the alaskite yielded an age of 604 ± 14 Ma (Wanless, personal communication, 1982). The older age is inferred to be closer to the time of intrusion and extensive deuteric alteration evident in the alaskite is inferred to have redistributed the Rb and Sr isotopes.

The Cambrian rocks in the northern Antigonish Highlands occur in a small fault-bounded pull-apart basin produced by dextral movements on the NE-SW bounding faults (Murphy and others, in press). They have been divided into two groups: the mainly sedimentary, 675 ft (225 m) thick, Iron Brook Group and the predominantly volcanic, 1500 ft (500 m) thick, McDonalds Brook Group (Murphy and others, 1982; in press). At the base of each group, red, nonmarine conglomerate, sandstone and slate (Black John and Malignant Cove Formations) unconformably overlie rocks of the Georgeville Group. In the Iron Brook Group, these redbeds are conformably overlain by interbedded red, green and black slate, thin limestone and quartzite. The limestones have yielded a late Early Cambrian fauna of trilobites and paraconodonts (Landing and others, 1980). Equivalent rocks in the McDonalds Brook Group are the biomodal, strongly alkalic, within-plate rift volcanic rocks (Keppie and Dostal, 1980; Murphy and others, 1985) and thin interbedded units of red slate, siltstone and fossiliferous limestone of the Arbuckle Brook

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Formation. The Little Hollow Formation is concordantly overlain by interbedded quartzite, ironstone and calcareous tuff of the Ferrona Formation which has yielded some inarticulate brachiopods: *Obolus (lingulobus) spissa* and *Lingulella(?)* of Late Cambrian - early Ordovician age (Williams, 1914). This suggests that an hiatus corresponding to the Middle Cambrian is present in the succession.

During the Ordovician, the Cambro-Ordovician rocks in the central part of the basin were affected by polyphase deformation which dies out toward the basin margins. This deformation consists of recumbent folds with a penetrative axial planar cleavage (defined by chlorite, muscovite and biotite) and accompanying thrusts, all of which were refolded by upright-inclined northwest-southeast trending folds. The deformation is inferred to be the result of sinistral motions along the northeast-southwest faults bounding the Cambrian pull-apart basin.

These deformed Cambrian rocks are unconformably overlain by the Arisaig Group. In the Arisaig area, the Late Ordovician-Silurian succession starts with 270-360 ft (90-120 m) of subaerial, bimodal, tholeiitic (-alkalic), within-plate rift basalts, rhyolitic flows, and ignimbrites with interbedded laterites of the Dunn Point and McGillivray Brook Formations (Boucot and others, 1974; Keppie and others, 1979). The rhyolites have yielded a whole-rock Rb-Sr isochron of 434 ± 15 Ma (recalculated from Fullager and Bottino, 1968). These rocks are disconformably to unconformably overlain by shallow marine conglomerate, sandstone, and siltstone of the Early Llandoverian Beechhill Cove Formation. The Beachhill Cove Formation lies unconformably upon the Iron Brook Group in Iron Brook. The Beechhill Cove Formation grades upwards into the Mid-Late Llandoverian black shale, muddy siltstone, tuff, and arenaceous limestone of the Ross Brook Formation. These formations are followed by shallow marine siltstone, shale, and limestone of the rest of the Arisaig Group. The total thickness of the Arisaig Group is about 3,800 ft (1,245 m). The Arisaig Group passes upward into >3,000 ft (>1,000 m) of generally non-marine silty mudstones, marls, sandstones, and conglomerates of the Early Devonian Knoydart Group. These Late Ordovician-Early Devonian rocks were deformed during the late Early-Middle Devonian by northeast-southwest, upright to asymmetric, gently to steeply plunging folds. The accompanying metamorphism is subgreenschist facies. Westward along the shore, Devono-Carboniferous rocks unconformably overlie all of the older units.

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SEDIMENTOLOGY, STRUCTURE, AND METALLOGENY OF THE GOLDENVILLE FORMATION, MEGUMA TERRANE, ISAACS HARBOUR, NOVA SCOTIA*

J. D. Keppie

This locality is one of the best sites to observe a wide variety of sedimentological, structural, and economic features in the Cambro-Ordovician Goldenville Formation, the lower unit of the Meguma Group, which forms a large part of the Meguma Terrane.

Sedimentological and Structural Features (Site XX)

The interbedded sandstones and slates of the Goldenville Formation at this locality display many features typical of turbidites, such as partial to complete Bouma sequences (a graded basal unit followed upward by a parallel-laminated sandstone, a crosslaminated sandstone that sometimes has convolute lamination, and a slate horizon), flute and groove casts, and dewatering structures (pipe and sheet structures leading upward to sand volcanoes on the upper surface of the sandstone beds). In contrast, the Halifax Formation is predominantly slate with thin sandstone interbeds. Graptolites recovered from the Halifax Formation indicate an Ordovician age.

This site also displays many of the structures present in the Meguma Terrane. The earliest structures include upright, monoclinal, cylindrical, and conical Acadian folds associated with a spaced and slaty pressure solution cleavage defined by chlorite, muscovite, and biotite, inferred to have formed by sinistral shear during the Early Devonian. These structures were substantially deformed by a subhorizontal crenulation cleavage preferentially developed in the slaty rocks. Decussate biotite porphyroblasts in the contact aureole of Late Devonian granitic plutons may be observed to have overgrown this crenulation cleavage. This was closely followed by, or was partly synchronous with tightening of the Acadian folds and reactivation of the Acadian cleavage during Late Devonian dextral shear deformation. This was synchronous with the start of westward obduction of the Meguma Terrane, which continued into Permian times (Dallmeyer and Keppie, in press; Keppie and Dallmeyer, in press). The Meguma Terrane is bounded along its northern margin by the Minas Geofracture, evidence of a lateral ramp that merges at depth with the thrust zone beneath the Meguma allochthon. The Minas Geofracture displays structures typical of a dextral shear zone (Keppie and others, 1985). During the Mid to Late Devonian, the Meguma Terrane was eroded and then unconformably overlain by about 1.8 mi (3 km) of Carboniferous rocks. Finally, during the early Mesozoic, the Meguma Terrane was displaced eastward along a listric normal fault that appears to coincide with the thrust at the base of the Meguma Terrane. The northwest-southeast faults and associated northwest-southeast sinistral kink bands along Isaacs Harbour and Country Harbour are believed to have formed at this time. The youngest structures are north-south shear joint zones. Stops A-C, I, K display primarily geological features.

Metallogenic Features (Site YY)

Five types of veins representative of those present in the Meguma Terrane, including those mined for gold, are present at this locality. They are (1) stratabound, laminated ribbon veins preferentially developed in the slaty horizons during the Acadian deformation; (2) en echelon veins in the limbs of the main Acadian folds formed by extension during flexural folding; (3) and (4) saddle reef and radial veins formed in tight Acadian fold hinges due to tangential longitudinal strain; and (5) north-south vertical veins, which generally cut across the Acadian structures but were gently folded and cut by the cleavage during the Late Devonian reactivation. Stops D-H, and J display features related to metallogenesis.

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*Also in Geological Society of America Centennial Field Guide-Northeast Section, 1986.

ANORTHOSITES AND GABBROIC BODIES IN NORTHERN CAPE BRETON ISLAND, NOVA SCOTIA*

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ABSTRACT

Several lensoidal anorthositic bodies of probable Precambrian age are exposed in northern Cape Breton Island within a central fault-bounded block of quartzofeldspathic gneisses. One of these, the Red River anorthosite complex (ca. 11 km long and up to 1 km wide), ranges from anorthosite to anorthositic gabbro with high Al_2O_3 and Sr contents and large positive Eu anomalies resulting mainly from plagioclase accumulation. The Red River cumulate-type anorthosite complex differs from those of the Grenville Province which are generally massif-type.

Following an episode of polyphase deformation and amphibolite facies metamorphism, a monzodiorite-gabbro body of unknown age was intruded into both the anorthosite and its host rocks. The geochemistry of this intrusion indicates that it is calc-alkaline. Granite sheets, intrusive into the monzodiorite-gabbro body, do not appear to be comagmatic based upon the trace element chemistry. These sheets may be correlated with granitic plutons in the Cape North area which have been dated as 330 ± 23 Ma.

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TWO Rb-Sr WHOLE ROCK ISOCHRONS FROM PLUTONS IN THE COBEQUID HIGHLANDS, NOVA SCOTIA, CANADA*

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ABSTRACT

Two Rb-Sr whole rock isochrons were obtained from plutons in the Cobequid Highlands of Nova Scotia: the Debert River and Hart Lake-Byers Lake Plutons. The undeformed, unfoliated Debert River Pluton yielded an age of 596 ± 70 Ma and an initial $^{87}Sr/^{86}Sr$ ratio of 0.7059 ± 0.0007. This age places an upper age limit on the deformation recorded in the Folly River Schist (youngest unit of the Bass River Complex), the dioritic Frog Lake Pluton, and the sedimentary rocks immediately north and east of the Debert River Pluton. The initial $^{87}Sr/^{86}Sr$ ratio and the biotite-hornblende content of the granite suggest a mafic igneous lower crustal component for the magma, although a mantle-derived component could also be involved.

The Hart Lake-Byers Lake Pluton yielded an age of 348 ± 5 Ma and an initial $^{87}Sr/^{86}Sr$ ratio of 0.7046 ± 0.0008. The similiarity of this age to the adjacent felsic volcanics of the Byers Brook Formation suggests that they are comagmatic and confirms that the Carboniferous igneous event forms an important part of the geological history of the Cobequid Highlands. The initial $^{87}Sr/^{86}Sr$ ratio and the hornblende (-biotite) content of the granite also suggests a mafic igneous lower crustal ± mantle source for the magma.

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Rb-Sr ISOTOPIC DATA FROM THREE SUITES OF IGNEOUS ROCKS IN CAPE BRETON ISLAND, NOVA SCOTIA, CANADA*

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ABSTRACT

Rb-Sr isotopic data are presented for three suites of igneous rocks from Cape Breton Island, Nova Scotia: Fourchu Group, Ingonish Island volcanics and Gulch Brook Pluton. Results from the Late Precambrian Fourchu Group metavolcanic rocks show considerable scatter due to varying degrees of resetting of the Rb-Sr system. Seven of the eight samples yielded a 407 ± 46 Ma age which is believed to reflect the effects of the Acadian Orogeny in this area. A two-point whole rock isochron from the two freshest samples yielded a ca. 640 Ma age which could approximate the extrusive age. The redistribution of strontium and rubidium isotopes suggests that the initial $^{87}\mathrm{Sr}/^{86}\mathrm{Sr}$ ratios in the range 0.703-0.705 should be viewed with caution.

A whole rock Rb-Sr isochron on volcanic rocks from Ingonish Island yielded an age of 412 ± 15 Ma interpreted to closely date the time of extrusion and crystallization. An initial $^{87}\mathrm{Sr}/^{86}\mathrm{Sr}$ ratio of 0.706 suggests the lower crust as one possible source region.

The 413 ± 10 Ma Rb-Sr whole rock isochron obtained from the weakly foliated Gulch Brook microgranitic pluton in northern Cape Breton Island probably represents the age of crystallization. Micas which define the weak foliation in the pluton have previously yielded an Rb-Sr mineral isochron of 320 Ma or individually calculated ages of 363 Ma for muscovite and 350 Ma for biotite (Cormier, 1980; written comm., 1984) and are believed to represent resetting by a later thermal event during the Late Devonian-Early Carboniferous. The initial $^{87}\mathrm{Sr}/^{86}\mathrm{Sr}$ ratio of 0.7045 ± 0.0004 suggests a lower crustal source for the magma, possibly with a mantle component as well. The similarity of the ages and initial $^{87}\mathrm{Sr}/^{86}\mathrm{Sr}$ ratios of the Ingonish Island volcanic rocks and the Gulch Brook Plutons suggests they may be volcanic/subvolcanic equivalents of one another.

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GEOLOGICAL HISTORY OF THE ANTIGONISH HIGHLANDS, NOVA SCOTIA*

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ABSTRACT

The Antigonish Highlands is bounded by major tectonic lineaments to the north and west (Hollow Fault) and to the south (Chedebucto Fault) and is unconformably overlain by Devono-Carboniferous rocks to the east. The highlands are predominantly underlain by Precambrian rocks of the Georgeville Group with Cambro-Lr. Ordovician (Iron Brook (IB) and MacDoanld Brook Group (MB)) and Upper Ordovician-Lower Devonian (Arisaig Group, AG) distributed at the margins of the highlands.

Precambrian rocks consist of subaerially deposited interlayered rhyolites, basalts and basaltic andesites overlain by a thick sequence of turbidites and minor basalts. The stratigraphic content and geochemistry of volcanic rocks suggests deposition in a basin in an extensional environment. Closure of the basin in the latest Precambrian resulted in polydeformation and greenschist facies metamorphism. Late Precambrian intrusive rocks are post-tectonic and consist of appinite (hornblende gabbro), alaskite, and mafic dyke swarms. The appinites are spatially associated with major faults.

Cambro-Lr. Ordovician rocks consist of fluviatile to shallow marine red clastics and fossiliferous limestones (IB) and a laterally equivalent sequence of bimodal volcanics (MB). These rocks unconformably overlie the Georgeville Group. They were deposited in a small pull-apart basin which was formed in a period of transpression during the latest stages of the late Precambrian orogeny. These rocks were polydeformed probably in the middle Ordovician.

The Arisaig Group consists of a bimodal volcanic sequence interlayered with red fluviatile conglomerates and arkoses and overlain by fossiliferous siliciclastics and minor rhyolites. The sequence records a marine transgression. The rocks were deposited in an extensional tectonic environment. The southern highlands were deformed by northwest and northeast trending conjugate shear zones and intruded by granite plutons in the middle Devonian. The deformation and plutonism may be attributed to the docking of the Meguma Terrane to the south along the Chedabucto Fault.

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AVALONIAN VOLCANIC ROCKS OF NOVA SCOTIA*

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ABSTRACT

The nature of Late Precambrian volcanic rocks in the Avalon Composite Terrane in Nova Scotia varies from one terrane to another: (i) in the Cape Breton Terrane, calc-alkaline basalts, andesites, rhyolites and pyroclastics characteristic of a cratonic volcanic arc are prevalent (Fourchu and Keppoch Formations) (ii) in the Antigonish Terrane, tholeiitic basalts (Chisholm Brook Formation) and oceanic island alkali basalts (Clydesdale Formation) occur in an interarc basin.

During transpression immediately following the accretion of these terranes into the Avalon Composite Terrane, bimodal alkali and tholeiitic, within-plate Cambrian volcanism occurred in small pull-apart rifts. Volcanism next occurred at the beginning of the Silurian with the eruption of bimodal, within-plate continental tholeiitic lavas associated with the minor rifting event preceding the Silurian transgression. Mid-Late Devonian and earliest Carboniferous volcanism in the Avalon Composite Terrane is typically bimodal, alkalic and tholeiitic, within-plate, and continental and formed in response to the rifting associated with the pull-apart Magdalen Basin produced during the Acadian Transpression Stage.

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PALEOZOIC STRUCTURAL DEVELOPMENT OF THE CANADIAN APPALACHIANS*

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ABSTRACT

In the Canadian Appalachians, deformation may be assigned to three 60-100 million year long orogenies: Taconian, Acadian and Alleghanian. The Taconian Orogeny, located along the NW side of the Appalachians, began during the Tremadocian with NNW then W obduction of newly formed oceanic lithosphere, with NE to SW diachronous involvement of the ancient North American continental margin during the mid-Ordovician ending during early Caradocian in Newfoundland and mid-Ashgillian in Quebec. A minimum convergence rate of 2 ± 0.4 cm/yr is estimated for a minimum total shortening of 450 ± 100 km. The Taconian Orogeny records the SE to E subduction of the western Iapetus and ancient North America beneath a volcanic arc.

The Acadian Orogeny, located along the SE side of the Appalachians, began during the Tremadocian with obduction of newly formed oceanic lithosphere, continued with SSE thrusting of oceanic and continental elements during the Late Ordovician, Silurian and earliest Devonian, finally involving the Avalon and Meguma Terranes in the Early to Mid-Devonian in a NE-SW sinistral shear zone. The Acadian Orogeny records NNW subduction of the eastern Iapetus and Baltica/Avalon beneath a volcanic arc.

The Alleghanian Orogeny is most intense along the SE side of the Canadian Appalachians migrating SW through time. It began in the Late Devonian, continued through the Carboniferous and into the Permian with W-directed thrusting. The Alleghanian Orogeny records E subduction of the Theic Ocean and an amalgamated North American/volcanic arc complex/Avalon/Meguma beneath Gondwana.

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DETRITAL ZIRCON AGES INDICATING A NORTH AFRICAN PROVENANCE FOR THE GOLDENVILLE FORMATION OF NOVA SCOTIA*

T. E. Krogh** and J. D. Keppie

ABSTRACT

U-Pb isotopic analysis of single detrital zircons and selected groups of similar zircon types provides a direct estimate of the age of the sediment source region. Uncertainties due to lead loss are reduced by abrading away all natural geological surfaces prior to analysis. Uncertainties related to common lead corrections are minimized by utilizing unprecedented low contamination chemistry. (Total common lead per analysis of 5 ± 3 picograms including lead from the sample has been achieved).

Results for zircons from two sub-greenschist facies samples from the Goldenville Formation in Nova Scotia indicate that two main age provinces are represented, one about 600 Ma old and another 2000 to 2700 Ma old. Sphene from the same samples comes primarily from the 600 Ma terrain. These results support the North African provenance as suggested by Schenk (1981) and indicate that the Sm-Nd model age (1773 ± 95 Ma) of Clarke and Halliday (1985) results from mixing of material from the two age provinces.

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GOLD IN PALEOZOIC BASALTIC ROCKS OF NOVA SCOTIA*

J. Dostal** and J. D. Keppie

ABSTRACT

In the Avalon Zone, the volcanic rocks are Early-Middle Cambrian, Late Ordovician - Early Silurian, Middle and Late Devonian in age, whereas in the Meguma Zone they are limited to the Late Ordovician - Silurian. In general, the Paleozoic volcanic rocks of Nova Scotia are biomodal, tholeiitic - alkalic and within - plate. The basaltic rocks were analyzed for gold by neutron activation using a pre-concentration method. In general, the gold concentrations are within the range of equivalent recent basalts. However, certain suites show marked enrichment by more than an order of magnitude. There appears to be little correlation of gold with major and trace elements, which negates a close relationship with constituent major rock-forming minerals and sulphides. There is also no obvious relationship with metamorphic grade. Gold concentrations and factors controlling its enrichment will be presented.

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ACCRETION AND DISPERSION OF NORTHERN APPALACHIAN TERRANES*

J. D. Keppie

ABSTRACT

In the northern Appalachians, a collage of terranes occurs between the ancient North American miogeocline and the Avalon Composite Terrane. Along the western margin of the orogen, they consist of oceanic lithosphere and continental rise deposits. Southeast of the Baie Verte-Brompton Line, a wide variety of terranes occur, including fragments of volcanic arcs and periarc basins, microcontinents, submarine plateaux and small ocean basins. The Avalon Composite Terrane consists of disrupted fragments of Late Precambrian terranes (volcanic arcs, periarc basins and cratonic blocks) overstepped by small outliers of comparable Cambro-Ordovician rocks. Outboard of the Avalon Composite Terrane lies the turbiditic Meguma Terrane.

Seismic data indicates that the structure of the northern Appalachians basically consists of a thin-skinned pile of nappes cut by steep faults. Correlation charts indicate that the terranes west of the volcanic arcs were accreted by NW/W obduction during the Ordovician Taconian Orogeny; while terranes between the volcanic arc terranes and the Avalon Composite Terrane were accreted by SSE obduction during the Ordovician-Devonian Acadian Orogeny. The dislocation along the northern side of the Avalon Composite Terrane formed during dispersion as Baltica and Avalon moved northwards relative to North America along a sinistral megashear during the Devonian. Other NE-SW transcurrent faults formed at this time. Finally, in Late Devonian-Permian times, westwards thrusting affected the entire width of the Appalachians in response to continent-continent collision between North America and Gondwana during the Alleghanian Orogeny.

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*Also in Abstracts with Programs, Geological Society of America, 1986, v. 18, p. 655.

LATE PALEOZOIC ACCRETION OF THE MEGUMA TERRANE WITH NORTH AMERICA*

J. D. Keppie and R. D. Dallmeyer**

ABSTRACT

The Meguma Terrane is represented by a sequence of Cambrian-Ordovician turbidites together with Late Ordovician-Early Devonian shelf sediments and intercalated rift-facies volcanic rocks. These were all deformed by upright folds with attendant development of an associated continuous cleavage in a sinistral shear regime prior to intrusion of granitoid plutons. The plutons and associated contact metamorphic aureoles were deformed by discrete, dextral shear zones. The deformed Meguma sequences are unconformably overlain by continental to shallow marine, Carboniferous sedimentary rocks which are in turn unconformably overlain by Mesozoic red bed sequences and plateau basalts. Results of a comprehensive geochronological program indicate: (1) formation of the early continuous cleavage occurred between c. 385 and 410 Ma; (2) intermittent emplacement of granitoid plutons between c. 375 and 260 Ma; and (3) development of dextral shear zones between c. 375 and 260 Ma. Significant Sn-W-U mineralization is locally associated with the younger plutons and appears to be spatially related to dextral shear zones.

Seismic data indicater that the Meguma Terrane occurs above a SE-dipping decollement which surfaces in the Bay of Fundy. It is bounded on the north by the Minas Geofracture which represents a lateral ramp which was active between c. 365 and 375 Ma. A minimum westward displacement of c. 500 km is suggested for the Meguma Terrane during c. 375-260 Ma. This indicates an average rate of obduction of c. 0.5 cm/yr. Emplacement of the Meguma Terrane depressed the lithosphere and disrupted the continental geothermal structure. Reestablishment of thermal equilibrium led to local increase in temperature with resultant production of anatectic granites.

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*Also in Abstracts with Programs, Geological Society of America, 1986, v. 18, p. 655.
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METALLOTECTONIC MAPS: THE ECONOMIC POTENTIAL OF TERRANE ANALYSIS*

J. D. Keppie

ABSTRACT

Metallogenic and metallotectonic maps attempt to relate mineral deposits to tectonic setting, initially within the framework of geosynclinal theory but now replaced by plate tectonic theory. These maps are interpretive in contrast to the more factual mineral occurrence and metal province maps. In the same way, a Tectonic Map illustrates the evolution of the outer part of the Earth through time and is interpretive, whereas geological and structural maps are more factual. A Tectonic Element is defined as a specific, tectonic environment characterized by a distinct tectono-stratigraphic or tectono-plutonic rock unit. A Metallotect is defined as a genetically related group of metals which is cogenetic with a Tectonic Element. Tectonic Elements and Metallotects may be grouped into several Tectonic Stages, e.g.:

STAGE	METALLOTECT		
Stable	stratabound Fe-Mn	in	epicontinental basin
	conglomerate U-Au	in	intracontinental basin
Collision	Sn-W-U-F-Mo-Au	in	collision plutons
	pegmatitic Nb-Ta	with	collision plutons
	Au-Zn-Mn veins	in	collision structures
	sandstone U-Cu-V stratabound Pb-Zn-Cu	in	foreland, hinterland and intramontane basins
	U-Fe-Th-REE-Sr-Ba	in	alkalic volcanic rift
Subduction	alluvial Au-Sn	in	retroarc compressive basin
	Au-Hg-F-Sb volcanics	in	retroarc extensional basin
	P black shale	in	backarc basin
	Cu-Fe-Zn basalts	in	backarc basin
	Cr ultramafics	in	backarc upper mantle
	Besshi-type Cu-Zn	in	backarc basin seamount
	Hg-Au-Te andesites	in	volcanic arc
	Sb-W-Hg basalts	in	volcanic arc
	Fe-apatite rhyolites	in	volcanic arc
	Kuroko-type Zn-Pb-Cu	in	volcanic arc rift
	Cu-Au-Mo porphyry	in	magmatic arc
	placer Au	in	forearc basin
	Hg-Sb-W flysch	in	forearc basin
	Au veins	in	trench complex
Spreading	Mn-Ni-Co nodules	in	oceanic crust layer 1
	Cu-Fe-Zn basalts	in	ocean crust layer 2
	Cu-Ti gabbro	in	ocean crust layer 3
	Ni-Cr-Pt ultramafics	in	upper mantle
	Cyprus-type Cu-Fe-Zn	in	ocean transform
	placer Ti-Zr	in	continental shelf
	Pb-Zn carbonates	in	continental shelf
	banded iron formation	in	continental shelf
Rift	Cu-U-REE carbonatite	in	within-plate pluton
	alkaline U-Sn-Nb	in	within-plate pluton
	sandstone U	in	rift valley
	Sullivan Ag-Pb-Zn	in	rift valley

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*Also in International Conference on Iberian Terranes and their Regional Correlation, 1986; IGCP Project 233, University of Oviedo, Spain, p. 90.

DEFORMATION ASSOCIATED WITH ACCRETION AND DISPERSION: IMPLICATIONS FOR TERRANE ANALYSIS*

J. D. Keppie

ABSTRACT

The dominant mechanism of accretion is oblique underthrust deformation at one or more subduction zone. Subduction of normal oceanic lithosphere results in a narrow plane of deformation between the two plates. With progressive underplating, this plane of deformation may migrate progressively downwards producing diachronous deformation. With the arrival of terranes at the trench, this single deformation plane is gradually replaced by a wide zone of synchronous thrust-related deformation in both plates. The extent of this wider zone of deformation is directly related to the size of the accreting terrane. Resistance to terrane subduction may eventually result in relocation of the trench. Post-accretionary dispersion takes place mainly by transcurrent faulting, which slices up the nappe stack resulting in the superimposition of vertical terrane boundaries upon the initial subhorizontal boundaries.

Implications for terrane analysis are:
(i) terrane boundaries on a map are often the dispersive transcurrent faults with a small component of vertical displacement, the thrust terrane boundaries are hidden over large areas;
(ii) as all deformation is essentially in shear zones, its absence in any one area does not necessarily imply that the regional deformation or phase of subduction has ceased;
(iii) as the main deformation in orogens is associated with accretion, it is generally not an unique characteristic of a specific terrane because it affects terranes on both sides of a boundary - an exception is the case where a fragment of an older orogen is accreted to an area where this orogeny was absent;
(iv) the general concept of diachronous deformation clearly contradicts the present convention of assigning structures across an entire orogen to broadly synchronous, short-lived phases of deformation, such as Acadian, Grampian, Ligerian, Scandian, etc.; in fact, deformation is more likely to be long-lived and spatially linked to a subduction zone, only becoming widespread during the final continent-continent collision;
(v) while, ideally one should distinguish deformation associated with distinct subduction zones, and this is possible for the earliest stages of convergence, it is extremely difficult to do so (a) once convergence reaches the collision stages because of the widespread deformation superimposed during terrane accretion; (b) the distinct possibility that two trenches in any one section of the orogen may connect with one another on the map projection; and (c) the difficulties in uniquely dating the time of deformation especially in reactivated zones.

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*Also in International Conference on Iberian Terranes and their Regional Correlation, 1986; IGCP Project 233, University of Oiredo, Spain, p. 14.

POLYPHASE LATE PALEOZOIC TECTONOTHERMAL EVOLUTION OF THE MEGUMA TERRANE, NOVA SCOTIA*

R. D. Dallmeyer and J. D. Keppie**

ABSTRACT

Results of a comprehensive, multidisciplinary geochronological program in the Meguma Terrane suggest a complex, polyphase Late Paleozoic tectonothermal evolution. $^{40}Ar/^{39}Ar$ incremental-release ages of whole-rock slate/phyllite and green amphibole from calcsilicate range from 385 to 405 Ma. These are interpreted to closely date D_1 deformation and associated greenschist facies metamorphism. D_1 fabric elements are regionally overprinted by low-pressure, contact metamorphic aureoles which developed during emplacement of a series of granitic plutons between 360 and 375 Ma. Where unaffected by subsequent metamorphism, biotite and muscovite from the plutons and aureoles record 350-375 Ma plateau dates. Systematic regional differences in cooling followed intrusion. Dynamically recrystallized biotite and muscovite within dextral shear zones developed along the Minas Geofracture record 360-370 Ma plateau ages, suggesting accretion of the Meguma and Avalon Composite Terranes occurred immediately following initial phases of plutonism.

In western portions of the Meguma Terrane, granitic plutonic activity continued throughout the Late Paleozoic, with intrusion locally dated at ca. 350, 320, 290 and 270 Ma. Interference of associated contact metamorphic aureoles produced a complex isograd pattern and variably reset mineral argon systems. Preliminary data suggest that significant Sn-W-U mineralization may have developed preferentially in association with the later phases of thermal activity. Dynamically recrystallized biotite and muscovite within the Deerfield and Barrington dextral shear zones record plateau ages of 315-325 Ma and 275-285 Ma respectively. These indicate that locally penetrative ductile strains accompanied the various episodes of Late Paleozoic thermal activity. The protracted Late Paleozoic tectonothermal record within the Meguma Terrane is interpreted to have developed during the progressive westward obduction onto the continuously accreting North American margin.

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*Also in Geological Society of America Program with Abstracts, 1986, v. 18, p. 11.
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A NEW LOOK AT GEOCHEMICAL ANOMALIES*

P. J. Rogers

ABSTRACT

Areal proportions of mapped lithologic units are used as independent variables in a regression equation to predict the element content of stream sediments. Geochemical variation due to average differences in chemical composition between lithologic units is removed from the data, highlighting anomalies due to mineralization and to secondary processes active in the surficial environment. For the Cobequid Highlands lithologic effects explain between 30% and 65% of the variance, depending on the element chosen. The effects of scavenging metal ions by Fe and Mn in the secondary environment are also removed by regression. Co, Ni and As show particularly strong associations with Fe and Mn.

Regression experiments also show that if geologic map units are recorded as present or absent (1 or 0) in each basin, instead of using area measurements, the proportion of variance explained is almost as large. However, using only the most areally abundant unit in each basin results in about 25% less efficient prediction and similar results are obtained using only the presence of the map unit closest to each sample point.

Co-occurrence of certain map units in a catchment basin appears to be a relatively important factor for predicting Zn. Co-occurrence of units is represented in the regression equation by using cross-products of lithologic variables in presence/absence form.

A method for obtaining a weighted mean and weighted dispersion for the element contents characterizing each map unit is proposed. These values are more easily interpreted than those from regression coefficients, which suffer from very large variances for map units which cover only small areas.

A catchment basin map showing positive Zn anomalies after removing geological background and secondary effects due to Fe and Mn scavenging is shown as a grey-tone image, using a percentile scale. Digitization of geologic and catchment basin maps allows routine production of colour or grey-tone images depicting measured or derived geochemical parameters and provides a powerful tool for geochemical exploration.

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REGIONAL LAKE SAMPLING SURVEYS: GEOCHEMICAL EXPLORATION AND METALLOGENESIS IN THE MEGUMA ZONE, SOUTHERN NOVA SCOTIA*

P. J. Rogers and R. Mills

ABSTRACT

About 3400 samples from a previous regional centre-lake bottom sediment survey of southern Nova Scotia were reanalyzed for Cu-Pb-Zn-Ag-Li-F-Nb-Sn-Ti-Zr-Rb-Th-Sb-As-W-Au. The results confirm that most known deposits and metallogeny in the Meguma Zone have detectable geochemical signatures in lake sediments. New exploration targets for potential Au and Ag mineralization in granitoid rocks and W in Meguma Group metasediments were found using regional computer colour contour plots from the dataset. Multielement statistical analysis was used to identify areas of buried or weak anomalies and anomalous groupings of associated elements and to greatly assist in defining follow-up study areas. The centre-lake bottom sediments contain hydromorphically and mechanically dispersed components and are especially useful when prospecting for lithophile related mineralization. The detailed till mapping available indicates local and translated lake sediment anomalies at East Kemptville and the Halifax Peninsula.

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ANOMALY ENHANCEMENT USING CATCHMENT BASIN ANALYSIS ON SURFICIAL GEOCHEMICAL DATA FROM THE COBEQUID HIGHLANDS, NOVA SCOTIA*

P. J. Rogers, G. F. Bonham-Carter** and D. J. Ellwood**

ABSTRACT

The exploration geochemistry of the Cobequid Highlands, Nova Scotia, has been investigated using about 1,500 regional stream sediment and water samples. This study uses the catchment basin approach to anomaly recognition, integrating bedrock geology, topographic and drainage data with geochemical data. However, instead of confining the analysis to one element at a time, principal component analysis (PCA) has been employed so that element associations and their relationship to bedrock geology can be examined. This represents a further step towards the goal of integrating surficial geochemical data with spatial information from a geological map.

In most geochemical surveys, stream sediment data are either represented as single point values or spatially contoured at the regional scale by interpolating away from sample sites. In this study each catchment basin is treated as the zone of influence for the sample point defining the basin. Each sample can then be described not only by its location and chemical composition, but also by the geological composition and total area of its catchment basin. Regression experiments show that a large proportion of the variance in the data set can be explained by predicting the levels of a geochemical element from the rock-type areas. For the Cobequid Highlands data, between 25 to 65 per cent of the total variance can be solely attributed to areal proportions of mapped geological units. Scavenging in the secondary environment of elements by Fe and Mn oxides and hydroxides along with pH effects are also being considered in this approach.

The application of this technique for removal of known attributable factors such as catchment geology and scavenging is important at the anomaly definition stage of a regional geochemical survey. The application of PCA to datasets, after removing the effects of catchment geology and scavenging, allows significant enhancement of areas with associated multi-element anomalies and the detection of the exploration potential of individual lithologies. Element associations determined using PCA on the original dataset (before removing geological and other effects) are found to occur within certain lithologies in the study area. A follow-up geochemical survey in these areas, determined without removing geological and other effects, would sometimes lead to the investigation of spurious anomaly patterns, especially for Fe-Mn-Ni-Co-As-Cu and Cu-Pb-Zn associations in this case. Principal component scores calculated for each sample location allow anomaly patterns related to individual catchment basins to be produced, and to be displayed using computer generated plots. Previously unsuspected mineral potential for Au and polymetallic element associations is revealed for Carboniferous sedimentary units. The Devono-Carboniferous volcanics and granites seem to have most exploration promise in their contact areas.

The Cobequid Highlands study demonstrates the application of data integration techniques to surficial geochemical data. Details of catchment basin lithology and secondary scavenging are removed by regression analysis prior to multivariate analysis to avoid creating false anomalies. In Appalachian terrains, stream sediment regional geochemistry can be a powerful exploration tool in the search for anomalous metal patterns.

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REGIONAL STREAM SEDIMENT SAMPLING AND ANOMALY PATTERNS IN NOVA SCOTIA, CANADA: EXAMPLES FROM SELECTED STUDY AREAS*

P. J. Rogers

The Meat Cove zinc deposit exhibits skarn type mineralization with elevated levels of Zn, Cu, Pb, Fe, Hg, Cd, As and Ni in the ore zone. Stream sediment samples taken at linear intervals of 350 m were analyzed by Atomic Absorption Spectrometry (AAS) and Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES). Downstream from the deposit the stream sediments are enriched in Zn, Pb, Ag and As and depleted in Cu, Ni, Co, Mn, Mo, Fe and U. A geochemical "fingerprint" for the deposit was obtained using Spearman rank correlation coefficients (Rogers and MacDonald, 1983). Bar diagrams for selected elements at Meat Cove show a noticeably higher anomaly/background contrast for AAS when compared to ICP-AES. Depletions in K, P, Ti, Na and Sr in the stream sediments can be considered negative anomalies. For skarn deposits, like Meat Cove, ICP-AES is a useful exploration tool.

The Cobequid Highlands data integration study is a joint project between the Nova Scotia Department of Mines and Energy, and the Geological Survey of Canada. In most geochemical surveys, stream sediment data are either represented as a single point value or spatially contoured at the regional scale using various and complex mathematical transformations. Each catchment basin (Rose, 1975) is treated as the zone of influence for the sample point. For each basin, raw element content and residual colour maps are produced. After step wise regression, variance explained by areal proportion of rock type (i.e. mapped catchment basin lithology) and secondary scavenging by Fe-Mn hydroxides and oxides is assessed. For the Cobequid data, between 20 to 65% of total variance can be solely attributed to areal proportions of mapped geological units. Scavenging by Fe and Mn oxides and hydroxides and pH effects are detected in the data. For Zn, 12.75% of the total variance is explained by secondary scavenging (Bonham-Carter et al., in press). Application of this technique, which includes the removal of factors attributable to catchment geology and scavenging, is vitally important at the anomaly definition stage of regional geochemical surveys. The catchment basin residual plots define areas of positive anomalies for follow-up studies.

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*Paper presented at International South European Exploration Symposium, Athens, Greece, November 9-11, 1986.

1980s GEOCHEMICAL EXPLORATION IN THE NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY*

P. J. Rogers

ABSTRACT

The application of exploration geochemical methods to mineral prospecting in Nova Scotia uses various sampling media such as stream and lake sediments, their related waters, soils, tills, humus, gases and heavy minerals. This entails the widespread use of computers, which are inexorably bound to the operation of exploration geochemistry from the field into the office and to the publication of results. The main purpose of exploration geochemistry is to define an anomaly or group of anomalies which is essentially a series of unexplained numbers and can be due to a wide variety of causes. It is by having full confidence in the anomalous values produced by the use of computer technology in geochemical surveys that these statistical phantoms might be converted into something worthy of more detailed follow-up work. Geochemical surveys in Nova Scotia can be considered in three levels of increasing intensity of application of computer technology which will be illustrated by data from case histories.

Detailed studies of selected areas were performed using a microcomputer-based modelling approach to assess anomaly causing factors. This was largely done with commercial software packages such as Lotus and DBase 3. The Meat Cove case study illustrates the usefulness of a detailed orientation survey and its application to sampling design, new field sampling methods, geochemical fingerprinting, anomaly recognition and new analytical techniques. At East Kemptville lithogeochemical studies have demonstrated significant roles for specialized granites as vectors for Sn-W-U-Mo-Ag mineralization. A pilot study indicated mechanical dispersion of refractory cassiterite grains into lake catchment basins. Anomaly patterns in the study dataset confirm the important role lithophile elements have in outlining areas of specialized granites and potential mineralization. The panning of stream sediment samples is attractive in terms of size and lower sample preparation costs when compared to bulk samples. However, because of the limitations of material loss, operator dependency, qualitative results and high degree of skill required for panning, a bulk sample is recommended.

Regional geochemical compilations at the next scale of processing involve the use of micro and mainframe computers to perform statistical analysis and the display of these results with monochrome and colour plotters. In southern Nova Scotia, Applicon colour computer plots are used to detect gross geochemical trends. A multiple rating score, obtained by summing each element score, is used to plot a multielement map. The multielement approach is useful to detect buried or blind orebodies where they are subtly expressed, perhaps as leakage or weak anomalies. A number of important associations are noted throughout the dataset and their regional plot defines geochemically active areas. It is possible to detect areas of distinct metallogenesis and to indicate new exploration targets.

The final level of computer applications is the use of spatial data integration methods to produce a geochemical atlas. The Cobequids study illustrates newly revived concepts of anomaly recognition using computer based data integration, image analysis and multivariate statistical techniques to detect and enhance anomalies. Map digitizing and computer colour plotting methods were applied to the Cobequid data after statistical analysis. The application of catchment basin analysis (CBA) has focused principally on the removal of background due to bedrock geology and effects due to scavenging of metals by Fe and Mn for individual elements. Using Principal Component Analysis (PCA) and CBA, integration of geological data with multi-element components can be achieved. Using CBA it is possible to filter out not only lithologic and scavenging effects but also define areas of lithologic units with elemental associations of exploration interest. The factor score residual plots provide an excellent visual portrayal of potential anomalies and their distribution.

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INTEGRATED MINERAL EXPLORATION USING CATCHMENT BASIN ANALYSIS, COBEQUID HIGHLANDS, NOVA SCOTIA*

P. J. Rogers, G. F. Bonham-Carter and D. J. Ellwood****

A pilot study previously reported in Bonham-Carter et al. (in press) and Rogers et al. (1986) discussed the application of catchment basin analysis to the integration of surficial geochemistry with bedrock geology using image analysis. In this paper we report on an extension of this work to (a) cover a larger area, (b) further refine the method for characterizing geochemical background for the regional survey and (c) include a measure of variability based on field duplicates.

The Cobequid Highlands of northern Nova Scotia comprise an elongated area 160 km E-W by 50 km N-S, rising to a maximum of 350 m above sea level. A central core of Precambrian and Lower Paleozoic schists, gneisses, volcanics and sediments is intruded by numerous Devono-Carboniferous granitoids. The highlands are bounded to the south by the major Cobequid - Chedabucto Bay fault system and to the north by the Cumberland Basin. The flanking lowlands comprise Late Paleozoic to Mesozoic rocks. Known mineralization has been identified in various significant associations, including Cu-U sandstone hosted deposits, fault-related Mn deposits, poorly understood vein deposits containing precious metals, and polymetallic vein deposits. Mapping at 1:50 000 scale has identified about 65 rock units. This bedrock map has been raster scanned and the resulting digital image is 3335 x 960 pixels (50 m/pixel).

A 1983 regional stream sediment geochemical survey collected about 1500 -80 mesh samples, at an average density of 1 sample per 2.5 km^2. These samples were analyzed for Cu, Pb, Zn, Ag, Fe, Mn, Ni, Co, As, Hg, U and Mo in sediments; U, F and pH in surface waters. Field duplicates were collected at 1 site in 20. One of each duplicate pair was split to act as the analytical control.

Sample locations were plotted on a 1:50 000 stable base topographic map and catchment basins upstream from each site outlined by hand. The resulting map was also raster scanned to produce a second image in registration with the geological base. A computer file describing the geochemical composition of each sample and the geological composition (map units) of its associated catchment basin was created. Field sampling strategy included some nested basins, so samples are not necessarily geochemically or statistically independent from one another.

Coloured maps from an Applicon ink jet plotter using a percentile scale were made for each element. Each catchment basin was coloured according to the sample value, instead of using symbol plots or interpolation schemes which normally assume that the area of influence is centred on the sample location.

These plots reveal broad trends related to major structural features and stratigraphic units. The first 3 principal components of the logarithms of the element data (explaining 64% of variance), plotted as factor scores with each factor as one of 3 primary colours, reveal a number of distinct geochemical provinces. These geochemical provinces are of distinct geological composition, and the plots provide a valuable summary of background geochemistry and its relationship to geology and structure.

The relationship between element concentration and its variance has been modelled using the field duplicates. This permits estimation of 95% confidence limits for cutoff values between colour classes, for untransformed single element plots.

Regression analysis has been used to model background effects for each element using areal proportions of mapped units as independent variables. After removing background, residual maps enhance the definition of anomalous areas and aid in target selection for exploration. Tables showing average background response for each unit are produced.

Catchment basin plots not only provide an insight into the spatial variation of multi-element associations and their geological control, but also isolate potential exploration targets which can then be integrated with other data sources, such as remotely-sensed radar and airborne geophysics. The ultimate goal of this integration study is to produce target area maps based on ore deposit models.

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**Geological Survey of Canada, Ottawa, Ontario

LATE-GLACIAL CLIMATIC OSCILLATION IN ATLANTIC CANADA EQUIVALENT TO THE ALLEROD/YOUNGER DRYAS EVENT*

R.J. Mott**, D. R. Grant**, R. Stea and S. Occhietti***

ABSTRACT

Attempts to relate late-glacial events in northeastern North America to the well-documented climato- and chrono-stratigraphy of Europe and the British Isles have not been considered convincing because the evidence presented was from isolated sites, and could therefore be interpreted as local fluctuations not related to a general, widespread climatic change. However, recent palynological studies in northeastern North America postulating a late-glacial climatic oscillation have caused renewed interest in relating such an oscillation to the Allerod/younger Dryas event. We have extended our preliminary results from Nova Scotia and New Brunswick and here present the evidence for a climatic event in Atlantic Canada. This event involved a warming trend before 11,000 yr BP that was interrupted by a cold period which persisted until the abrupt Holocene warming at 10,000 yr BP. We propose a possible mechanism to link this event with that of Europe.

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TILL AND BEDROCK Cu-Pb-Zn GEOCHEMISTRY IN NORTHERN NOVA SCOTIA AND ITS METALLOGENIC IMPLICATIONS*

R. R. Stea, T. E. Day** and R. J. Ryan

ABSTRACT

Two surface till units, the Eatonville Till and an unnamed stony till sheet, were identified during a Quaternary mapping program in northern mainland Nova Scotia. These texturally and lithologically distinct till units have unique chemical signatures in the clay fraction.

The Eatonville Till, which covers the Carboniferous Lowlands, is composed of varying percentages of red and grey sandstone clasts with a red silty matrix. Cu, Pb and Zn levels are lower in the red sedimentary pebble facies in comparison to the grey sedimentary pebble facies. Areas of Eatonville Till which have anomalously low Cu and Zn contents exist in the Carboniferous Lowlands, primarily over the Pictou Group redbeds. The till is largely derived from red sedimentary rocks of the Pictou Group, which have distinctly lower Cu values than grey beds in the same strata. The cause of depressed Cu values in the rocks and the derived till may be the mobilization of Cu during diagenetic groundwater alteration and reddening of the Pictou Group rocks. The numerous copper mineral occurrences in the Pictou Group suggest that the mobilized copper was precipitated along solution fronts and red-grey sandstone boundary areas.

In the Eatonville Till, concomitant Pb and Zn levels show the strongest correlation in the grey pebble facies. The reason for this strong correlation is an association of Pb-Zn mineral occurrences with grey sandstones. The grey sandstones of the Carboniferous Boss Point Formation host Pb-Zn mineralization and are the focus of many Pb and Zn till anomalies. Metal values in the clay fraction of the Eatonville Till appear to be controlled by pebble lithology or provenance.

The stony till sheet is composed of igneous clasts and is largely restricted to the Cobequid Highland region. It is characterized by elevated metal values and a Mg-Ni-Co-Mn-Cu elemental association derived from comminution and weathering of igneous clasts abundant in ferromagnesian minerals. Pb and Zn levels are strongly correlated in the stony till data set. The cause of elevated levels of Pb and Zn in the stony till may be widespread dispersal of mineralized fault and fracture zones during four major ice flows that affected the region.

The key to successful follow-up of these regional geochemical results is the understanding of the sequence of ice flows and recognizing the till units that were deposited by them.

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*Also in Prospecting in Areas of Glaciated Terrain, 1986; Institute of Mining and Metallurgy, p. 241-259.

**Day and Associates, Halifax, Nova Scotia

GEOLOGY OF THE GUYSBOROUGH-COUNTRY HARBOUR AREA, NOVA SCOTIA*

J. D. Hill**

ABSTRACT

Regional mapping at 1:10 000 scale indicates that the Country Harbour-Guysborough area is underlain by Meguma Group strata intruded by granite, tonalite and pegmatite. The Goldenville Formation could not be subdivided. The Halifax Formation is composed of graphitic schist stratigraphically overlain by quartz-muscovite schist containing a few thin coticule beds.

Seven granitic plutons were outlined, ranging from medium grained muscovite-biotite granite to aplitic muscovite leucogranite. Six small bodies of biotite tonalite, three of which contain abundant hornblende, are exposed along the margins of the granitic plutons. The age relationships between the plutonic rocks were not determined.

The area has been affected by two main phases of ductile deformation, separated by a period of porphyroblast growth and granitoid emplacement, and followed by major transcurrent faulting.

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*Also in Current Research, Part A, Geological Survey of Canada, Paper 87-1A, 1987, p. 415-422. Funded by Geological Survey of Canada, Lithosphere and Canadian Shield Division, Project 850016, under the Canada - Nova Scotia Mineral Development Agreement

**Geological Survey of Canada, Ottawa, Ontario

THE LATE HADRYNIAN JEFFERS GROUP, WESTERN COBEQUID HILLS, NOVA SCOTIA*

G. Pe-Piper**

ABSTRACT

Detailed mapping of the Late Hadrynian Jeffers Formation (Avalon Zone) has permitted its elevation to group status and subdivision into three formations: the Gilbert Hills, the Humming Brook and the Cranberry Lake. The volcanic Gilbert Hills Formation underlies and interfingers with deeper water argillite of the Humming Brook Formation and turbidite wacke and siltstone of the Cranberry Lake Formation. The Jeffers Group has a spatially inhomogeneous flat-lying cleavage, probably associated with thrust faults of Late Hadrynian age that were reactivited during the Acadian Orogeny. This thrusting, together with major strike slip faulting, has resulted in a complex distribution pattern for rocks of the Jeffers Group.

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*Also in Current Research, Part A, Geological Survey of Canada, Paper 87-1A, 1987, p. 573-580. Funded by Geological Survey of Canada, Lithosphere and Canadian Shield Division, DSS Contract 20 ST.23233-6-0051, under the Canada - Nova Scotia Mineral Development Agreement

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PRELIMINARY REPORT ON SEDIMENTOLOGY OF SANDSTONES, SLATES, AND BIOCLASTIC CARBONATE MATERIAL IN THE MEGUMA GROUP, MAHONE BAY, NOVA SCOTIA*

J. W. F. Waldron and M. Graves*****

ABSTRACT

Within the Cambro-Ordovician Meguma Group of Nova Scotia, there is a complex transition zone between the Goldenville Formation and the overlying Halifax Formation. In the transition zone, two members are well exposed in the Tancook Island area of Mahone Bay. The lower, Tancook Member, contains two intervals of interbedded turbiditic sandstone and slate, separated by an interval of laminated and bioturbated manganiferous slate. A sandy bioclastic limestone horizon near the top of the member contains shell and echinoderm debris. The overlying Mosher's Island Member consists mostly of hemipelagic laminated manganiferous slate. The transition zone records a progressive reduction in the supply of sand to the area by turbidity currents, and a concurrent decrease in the supply of dissolved oxygen at the sediment-water interface.

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*Also in Current Research, Part A, Geological Survey of Canada, Paper 87-1A, 1987, p. 409-414.
Funded by Geological Survey of Canada, Lithosphere and Canadian Shield Division, Project 760027, DSS Contract 27 ST.23233-6-0052, under the Canada - Nova Scotia Mineral Development Agreement
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GEOLOGY IN THE VICINITY OF THE LIME HILL ZINC OCCURRENCE, SOUTHWESTERN CAPE BRETON ISLAND, NOVA SCOTIA*

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ABSTRACT

Mapping at Lime Hill, Cape Breton, Nova Scotia has defined the presence of a gneissic complex which is distinct from adjacent, Hadrynian George River Group metasediments with which the Lime Hill rocks are normally correlated. The distinction is based on differences in metamorphic grade, texture, lithology, occurrence of intrusive phases and magnetic signature. The gneissic complex may be either an uplifted block of George River Group from a deeper structural level or a faulted-in segment of pre-George River basement of uncertain age.

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*Also in Current Research, Part A, Geological Survey of Canada, Paper 87-1A, 1987, p. 555-561.
Funded by Geological Survey of Canada, Project 860008, under the Canada - Nova Scotia Mineral Development Agreement

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PRELIMINARY REPORT ON GEOLOGY AND ON MINERAL OCCURRENCES IN PRECAMBRIAN CARBONATE ROCKS, CAPE BRETON ISLAND, NOVA SCOTIA*

J. R. Hill**

ABSTRACT

A program involving geological mapping and lithogeochemical sampling of Precambrian carbonate units belonging to the George River Group and related formations was conducted over selected areas of Cape Breton Island, Nova Scotia, in 1986. The work was carried out both on a regional basis and locally within areas of known metallic and non-metallic mineralization in order to compile a geological and geochemical database for the economic evaluation and lithological metallogenic categorization of all metacarbonate rocks. Preliminary geological results have shown that carbonate sequences examined throughout Cape Breton may be placed into three distinct metamorphic-stratigraphic assemblages. Traditional concepts conferring stratigraphic equivalence to all metacarbonate rocks underlying Cape Breton Island, regardless of sedimentary association or metamorphic environment must therefore be re-evaluated. It is also apparent from the mineral deposits study that many of the carbonate-hosted metal occurrences cannot unequivocally be classed as contact metasomatic in origin. In fact, few deposits show evidence of intrustive-hosted mineralization and/or alteration phases; while many, especially the deposits at Lime Hill and Meat Cove and the Currie and Barachois River Fe occurrences, show some characteristics of sediment-hosted mineralization.

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*Also in Current Research, Part A, Geological Survey of Canada, Paper 87-1A, 1987, p. 533-542.
Funded by Geological Survey of Canada, Project 860008, DSS Contract 34 S7.23233-6-0119, under the Canada - Nova Scotia Mineral Development Agreement

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GEOLOGY OF THE NORTHEASTERN AND CENTRAL CAPE BRETON HIGHLANDS, NOVA SCOTIA*

S. M. Barr, R. P. Raeside**, C. E. White** and**
W. Yaowanoiyothin**

ABSTRACT

Northeastern and central Cape Breton Highlands consist of three lithological zones. Northwest of the Wilkie Brook fault system are Grenville-aged anorthosite and gneisses of the Blair River Complex.

To the southeast lie younger gneisses of the Cape North Group and predominantly metasedimentary units southeast of the Aspy Fault. The latter include quartzofeldspathic gneisses, mafic and pelitic schists, semipelitic gneisses and subordinate orthogneiss. These units are intruded by undated gneissic plutons and a distinctive, probably Devonian, suite of granitic plutons. These plutonic rocks include abundant xenoliths and septa, many derived from the metasedimentary units to the west.

Separated from this central area by mylonite, a southeastern zone includes a regionally continuous amphibolite layer, felsic to intermediate volcanic and volcaniclastic rocks and slates. The, probably late Ordovician to early Silurian, megacrystic Cameron Brook Pluton intrudes this zone. The Devono-Carboniferous, megacrystic, Margaree Pluton forms the western margin of the area in the west-central Highlands.

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*Also in Current Research, Part A, Geological Survey of Canada, Paper 87-1A, 1987, p. 199-207. Funded by Geological Survey of Canada, Lithosphere and Canadian Shield Division, Contract 27 ST.23233-5-0009, under the Canada - Nova Scotia Mineral Development Agreement

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CONTRASTING PETROLOGY AND AGE OF TWO MEGACRYSTIC GRANITOID PLUTONS, CAPE BRETON ISLAND, NOVA SCOTIA*

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ABSTRACT

Although texturally and mineralogically similar, the Cameron Brook and Margaree plutons in the Cape Breton Highlands of Nova Scotia are not similar in age or petrogenesis. Based on Rb-Sr whole-rock isochrons, the Cameron Brook pluton is late Ordovician to early Silurian whereas the Margaree pluton is Devonian-Carboniferous. The Cameron Brook pluton contains plagioclase and less abundant alkali feldspar megacrysts which generally lack rapakivi texture. The Margaree pluton contains predominantly alkali feldspar megacrysts with widespread development of rapakivi texture. Chemical and isotopic characteristics of the two plutons are very different, suggesting different processes were involved in their development. Elevated potassium content and polybaric history during crystallization are thought to be mainly responsible for development of rapakivi texture in the Margaree pluton.

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*Also in Current Research, Part B, Geological Survey of Canada, Paper 86-1B, 1986, p. 179-190. Funded by Geological Survey of Canada, Mineral Resources Division, Project 700059, Contract 27 ST.23233-5-0403, under the Canada - Nova Scotia Mineral Development Agreement

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GEOLOGY AND MINERAL OCCURRENCES OF THE JUMPING BROOK COMPLEX, CHETICAMP - PLEASANT BAY AREA, CAPE BRETON ISLAND, NOVA SCOTIA*

H. E. Plint**, K. A. Connors** and R. A. Jamieson**

ABSTRACT

The Jumping Brook Complex is part of a belt of metamorphosed volcanic and sedimentary rocks which hosts small polymetallic sulphide deposits in northwestern Cape Breton Island. Detailed geological mapping (1:10 000) of the Jumping Brook Complex in the Cheticamp-Pleasant Bay area has been conducted in order to (1) document the structure, stratigraphy and metamorphism of the complex and its geological relationships to higher grade rocks to the east (Pleasant Bay Gneiss Complex), (2) determine the relative and absolute ages of the complexes, and (3) determine sulphide-host rock relations of three known deposits in the southern part of the map area. Bedding transposition and ambiguous younging indicators preclude determination of a depositional stratigraphy in the Jumping Brook Complex. Mafic pillow lavas have been documented in the southern part of the map area. A progressive, east to west, metamorphic increase from chlorite to staurolite-kyanite grade in the Jumping Brook Complex continues into the Pleasant Bay Gneiss Complex. All three sulphide occurrences are hosted by the metavolcanic rocks of the Jumping Brook Complex and two of the deposits are hosted by felsic tuffs. Sulphide-host rock textures indicate that mineralization pre-dates metamorphism and deformation, and is probably syngenetic. Locally, however, mineralization has been remobilized by shearing.

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*Also in Current Research, Part B, Geological Survey of Canada, Paper 86-1B, 1986, p. 557-566.
Funded by Geological Survey of Canada, Mineral Resources Division, Project 700059, Contract 27 ST.23233-5-0403, under the Canada - Nova Scotia Mineral Development Agreement

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GEOLOGY OF THE WEST BRANCH NORTH RIVER AND THE BOTHAN BROOK PLUTONS OF THE SOUTH-CENTRAL CAPE BRETON HIGHLANDS, NOVA SCOTIA*

A. M. O'Beirne-Ryan** and R. A. Jamieson**

ABSTRACT

The West Branch North River and Bothan Brook plutons are an intrusive complex of granodioritic to granitic rocks, in the south-central Cape Breton Highlands. Preliminary mineralogical, geochemical, and isotopic studies suggest that they represent a comagmatic suite of late Devonian age. The Sarach Brook shear zone divides the West Branch North River pluton into an upthrusted block of granodiorite in the west, and monzogranite in the east. Alteration, contamination, and deformational features are considered contributors to the observed chemical variability. Hematite-rich breccia zones in the West Branch North River monzogranite, and extreme alteration in the Bothan Brook granite, have been identified and warrant examination for their mineral potential.

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*Also in Current Research, Part B, Geological Survey of Canada, Paper 86-1B, 1986, p. 191-200. Funded by Geological Survey of Canada, Mineral Resources Division, Project 700059, Contract 27 ST.23233-5-0403, under the Canada - Nova Scotia Mineral Development Agreement

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STRONTIUM ISOTOPIC STUDIES OF ROCK AND MINERAL SAMPLES IN THE SHUBENACADIE BASIN, NOVA SCOTIA*

C. E. Ravenhurst, P. H. Reynolds** and M. Zentilli****

ABSTRACT

Mineral deposits and occurrences of lead, zinc, and/or barite that exist at the margin of the Carboniferous Shubenacadie basin of Nova Scotia, occur near the disconformity between the older Horton Group continental clastic rocks and the overlying Windsor Group marine carbonates. Strontium isotopic analyses of calcite and barite indicate that there is a genetic link between these mineral occurrences. The ore-stage minerals of the larger and/or higher grade deposits such as the Gays River Pb-Zn deposit, have a relatively high ^{87}Sr/^{86}/Sr ratio (= 0.712), suggesting a massive influx of a mineralizing fluid considerably different from Carboniferous marine water as recorded in the host carbonates (^{87}Sr/^{86}Sr = 0.708). Thus, strontium isotopic data have potential applications in prospect evaluation within this basin.

No unique source for the calcium or barium component of the mineralizing fluids can be ascertained.

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*Also in Current Research, Part B, Geological Survey of Canada, Paper 86-1B, 1986, p. 547-555.
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COMPUTERIZATION OF COAL EXPLORATION DATA FOR NOVA SCOTIA: A JOINT FEDERAL-PROVINCIAL PROJECT*

J. D. Hughes, D. J. MacNeil and P. Watson*****

ABSTRACT

The construction of computer files of coal exploration data for Nova Scotia's coalfields is underway through a co-operative Federal/Provincial project. Procedures and computer programs developed by the Geological Survey of Canada for its National Coal Inventory are used for data compilation, interpretation and storage. Products of this work in the short term will be the availability of consistently defined exploration data in a flexible information management system. In the longer term, deposit models suitable for geological, economic and environmental assessment will be developed by applying established methodologies to the analysis of these data. This will give planners in industry and government a flexible, high-resolution planning tool providing the capability for rapid identification of the location and quantity of coal resources that meet any combination of geological, quality, economic or environmental criteria.

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*Also in Current Research, Part B, Geological Survey of Canada, Paper 86-1B, 1986, p. 417-420. Funded by Geological Survey of Canada under the Canada - Nova Scotia Mineral Development Agreement

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***c/o Energy Resources Division, Nova Scotia Department of Mines and Energy, Halifax, Nova Scotia

APPENDIX I

OPEN ASSESSMENT REPORTS FOR 1986

84-001

GOLD, CLAM HARBOUR. ACADIA MINERAL VENTURES. REPORT ON GEOLOGY AND PROPOSED DRILLING PROGRAM, BY W. A. MACPHERSON, 1983. 6 PAGES, 1 MAP (PROPERTY LOCATION).

84-002

GOLD, MOUNT UNIACKE. PROSPEX INCORPORATED, CONSOLIDATED GOLDFIELDS LIMITED AND SELCO INCORPORATED (FOR PAN EAST RESOURCES INCORPORATED AND R. MARCHANT). REPORT ON TRENCHING, GEOLOGICAL MAPPING, AND A ROCK GEOCHEMICAL SURVEY, BY C. MILLER, 1984. 12 PAGES, 3 MAPS (PROPERTY LOCATION; ROCK GEOCHEMICAL; TRENCH GEOLOGICAL; TRENCH LOCATION).

84-003

GOLD, GOLDENVILLE. GOLDENVILLE EXPLORATIONS LIMITED (FOR W. L. YOUNG). REPORT ON GEOLOGICAL AND GROUND MAGNETIC SURVEYS AND DRILLING, BY B. E. JONES, 1984. 858 PAGES, 5 MAPS (DRILLHOLE LOCATION; MAGNETIC, GROUND; PROPERTY LOCATION), DRILLHOLE SECTIONS, DRILLHOLE LOGS.

84-004

GOLD, FIFTEEN MILE STREAM. PROSPEX INCORPORATED (FOR PAN EAST RESOURCES INCORPORATED). REPORT ON A GEOLOGICAL SURVEY, BY C. MILLER, 1984. 10 PAGES, 3 MAPS (BIOGEOCHEMICAL; GEOLOGICAL; MINE SURFACE PLANS; PROPERTY LOCATION).

84-005

BASE METALS, SIMPSON LAKE. SELCO INCORPORATED. REPORT ON GEOLOGICAL, ROCK GEOCHEMICAL, STREAM SEDIMENT GEOCHEMICAL AND STREAM SEDIMENT HEAVY MINERALS GEOCHEMICAL SURVEYS, BY C. B. MCKENZIE, M. CULLEN , 1984. 20 PAGES, 8 MAPS (GEOLOGICAL; HEAVY MINERALS GEOCHEMICAL; PROPERTY LOCATION; ROCK SAMPLE LOCATION; STREAM SEDIMENT GEOCHEMICAL).

84-006

GOLD, ISAACS HARBOUR. JAMES E. TILSLEY AND ASSOCIATES LIMITED (FOR ISAACS HARBOUR GOLD EXPLORATIONS LIMITED, TRAFALGAR RESOURCE INVESTMENTS LIMITED AND W. LOCKERBY). REPORT ON GEOLOGICAL, GROUND MAGNETIC, GROUND VLF AND HAMMER SEISMIC SURVEYS, BY J. E. TILSLEY, 1984. 26 PAGES, 6 MAPS (EM, GROUND; GEOLOGICAL; MAGNETIC, GROUND; PROPERTY LOCATION; TRENCH LOCATION).

84-007

POTASH, ASHFIELD. NORANDA EXPLORATION COMPANY LIMITED. COMPILATION REPORT ON GEOLOGICAL, GRAVITY AND DRILLING INVESTIGATIONS IN THE RIVER DENYS SUB-BASIN, BY D. MACINNIS, P. M. DIMMELL, 1983. 24 PAGES, 10 MAPS (DRILLHOLE LOCATION; FOSSIL LOCATION; GEOLOGICAL; GRAVITY, AIRBORNE; GROUNDWATER GEOCHEMICAL; INDUSTRIAL MINERAL LOCATION; METALLIC MINERAL LOCATION; PROPERTY LOCATION; QUARRY LOCATION), GEOCHEMICAL PROFILES, DRILLHOLE SECTIONS, CORRELATION SECTIONS, STRATIGRAPHIC COLUMNS, GAMMA RAY LOGS, CALIPER LOGS, DENSITY LOGS, NEUTRON LOGS.

84-008

BASE METALS, FRENCH ROAD. M. RIDDELL. REPORT ON DRILLING, BY J. E. RIDDELL, 1983. 2 MAPS (DRILLHOLE LOCATION; EM, GROUND; GEOLOGICAL; PROPERTY LOCATION; STREAM SEDIMENT GEOCHEMICAL), HISTOGRAMS.

84-009

GOLD, PLEASANT RIVER BARRENS. J. S. VINCENT (FOR BEAR PASS RESOURCES CORPORATION). REPORT ON GEOLOGICAL SURVEY, ROCK AND SOIL GEOCHEMICAL SURVEYS, AND A GROUND EM SURVEY, BY J. S. VINCENT, 1984. 29 PAGES, 17 MAPS (EM, GROUND; GEOLOGICAL; MINE SURFACE PLANS; PROPERTY LOCATION; ROCK GEOCHEMICAL; SOIL GEOCHEMICAL; STRUCTURAL), HISTOGRAMS.

84-010

BARITE, WALTON. CUVIER MINES INCORPORATED. REPORT ON A GROUND IP SURVEY, GEOLOGY AND DRILLING, BY D. L. BLACK, 1984. 38 PAGES, 5 MAPS (DRILLHOLE LOCATION; IP; PROPERTY LOCATION; RESISTIVITY), DRILLHOLE LOGS, PSEUDO-SECTIONS, DRILLHOLE SECTIONS.

84-011

BASE METALS, NEW SALEM. V. BENNETT. PROSPECTOR'S NOTES, BY V. F. BENNETT, 1984. 7 PAGES.

84-012

BASE METALS, PARRSBORO. SELCO INCORPORATED. REPORT ON GEOLOGICAL, ROCK GEOCHEMICAL, STREAM SEDIMENT GEOCHEMICAL AND STREAM SEDIMENT HEAVY MINERALS GEOCHEMICAL SURVEYS, BY C. B. MCKENZIE, M. CULLEN , 1984. 21 PAGES, 13 MAPS (GEOLOGICAL; HEAVY MINERALS GEOCHEMICAL; PROPERTY LOCATION; ROCK SAMPLE LOCATION; STREAM SEDIMENT GEOCHEMICAL).

84-013

GOLD, CLAM HARBOUR. B. EISAN. PROSPECTOR'S NOTES, BY B. EISAN, 1984. 4 PAGES, 1 MAP (PROPERTY LOCATION).

84-014

GOLD, BIG ASS LAKE. J. MYERS. PROSPECTOR'S NOTES, BY J. MYERS, 1984. 2 PAGES, 1 MAP (PROPERTY LOCATION).

84-015

GOLD, BEAVER DAM. J. E. RIDDELL (FOR INTERNATIONAL GEOCHEMICAL ASSOCIATES LIMITED AND D. ALLEN). REPORT ON GEOLOGICAL EVALUATION, AND DRILL CORE LOGGING AND ANALYSES, BY J. E. RIDDELL, R. M. WHITELAW, 1984. 25 PAGES, 3 MAPS (DRILLHOLE LOCATION; PROPERTY LOCATION), DRILLHOLE LOGS, DRILLHOLE SECTIONS.

84-016

GOLD, CARIBOU. JAMES E. TILSLEY AND ASSOCIATES LIMITED (FOR GOLDEN CARIBOU EXPLORATIONS LIMITED AND JOHN LOGAN ENTERPRISES LIMITED). REPORT ON GEOLOGICAL, GROUND MAGNETIC AND GROUND VLF SURVEYS, AND TRENCHING, BY J. E. TILSLEY, 1984. 12 PAGES, 3 MAPS (GEOLOGICAL; MAGNETIC, GROUND; MINE SURFACE PLANS; PROPERTY LOCATION; VLF, GROUND).

84-017

GOLD, CARIBOU. TRI-EXPLORATIONS LIMITED. REPORT ON PROSPECTING AND FLOAT ASSAY RESULTS, BY J. E. DAWE, 1984. 23 PAGES, 9 MAPS (PROPERTY LOCATION; ROCK SAMPLE LOCATION), CROSS-SECTIONS.

84-018

GOLD, CARIBOU. TRI-EXPLORATIONS LIMITED (FOR M. E. X. EXPLORATIONS LIMITED AND SEABRIGHT RESOURCES INCORPORATED). REPORT ON PROSPECTING, TRENCHING AND DRILLING, BY D. L. BLACK, 1984. 36 PAGES, 2 MAPS (DRILLHOLE LOCATION; PROPERTY LOCATION; TRENCH GEOLOGICAL), DRILLHOLE LOGS, DRILLHOLE SECTIONS.

84-019

BASE METALS, COXHEATH. COXHEATH GOLD HOLDINGS LIMITED. REPORT ON THE ANALYSIS OF FRACTURE PATTERNS IN THE COXHEATH AREA, BY J. E. RIDDELL, P. BODOU, P. CHARPENTIER, 1984. 16 PAGES, 5 MAPS (IP; LINEAMENTS; METALLIC MINERAL LOCATION; STRUCTURAL), STRUCTURAL STEREOGRAMS.

84-020

BASE METALS, NORTHEAST MARGAREE VALLEY. BP RESOURCES CANADA LIMITED. REPORT ON GEOLOGICAL AND ROCK, SOIL, AND STREAM SEDIMENT GEOCHEMICAL SURVEYS, BY D. GOWER, 1984. 18 PAGES, 8 MAPS (GEOLOGICAL; PROPERTY LOCATION; ROCK SAMPLE LOCATION; SOIL GEOCHEMICAL; STREAM SEDIMENT SAMPLE LOCATION).

84-021

GOLD, MILL VILLAGE. ECOLOGICAL AND RESOURCES CONSULTANTS LIMITED (FOR SEABRIGHT RESOURCES INCORPORATED AND TRI-EXPLORATIONS LIMITED). REPORT ON PRODUCTION HISTORY AND PROPOSED EXPLORATION PROGRAM, BY W. E. HALE, 1984. 17 PAGES, 5 MAPS (DRILLHOLE LOCATION; PROPERTY LOCATION; SURFICIAL GEOLOGICAL).

84-022

TIN, SPECTACLE LAKE. BILLITON CANADA LIMITED (FOR W. B. DUNLOP). REPORT ON BOULDER PROSPECTING, A GEOLOGICAL SURVEY, AND ROCK AND TILL HEAVY MINERALS GEOCHEMICAL SURVEYS, BY G. B. DICKIE, 1984. 33 PAGES, 4 MAPS (GEOLOGICAL; METALLIC MINERAL LOCATION; PROPERTY LOCATION; ROCK GEOCHEMICAL; TILL GEOCHEMICAL), STRATIGRAPHIC CHARTS.

84-023

GOLD, LEIPSIGATE. J. E. RIDDELL (FOR INTERNATIONAL GEOCHEMICAL ASSOCIATES LIMITED AND TRAFALGAR RESOURCE INVESTMENTS). REPORT ON GEOLOGICAL EVALUATION AND PROPOSED DEVELOPMENT PROGRAM, BY J. E. RIDDELL, 1984. 12 PAGES.

84-024

GOLD, PLEASANT RIVER BARRENS. W. A. MACPHERSON (FOR BEAR PASS RESOURCES CORPORATION). REPORT ON PRODUCTION HISTORY, A GEOLOGICAL SURVEY, AND PROPOSED EXPLORATION PROGRAM, BY W. A. MACPHERSON, 1984. 20 PAGES, 6 MAPS (GEOLOGICAL; MINE SURFACE PLANS; PROPERTY LOCATION; STRUCTURAL).

84-025

TIN, NEW RUSSELL. KIDD CREEK MINES LIMITED. REPORT ON GEOLOGICAL, TILL AND SOIL GEOCHEMICAL SURVEYS, AND GROUND IP AND RESISTIVITY SURVEYS, BY D. R. DUNCAN, 1984. 26 PAGES, 13 MAPS (GEOLOGICAL; PROPERTY LOCATION; SOIL GEOCHEMICAL; TILL GEOCHEMICAL), RESISTIVITY PROFILES, IP PROFILES.

84-026

TIN, CHRISTY LAKE. KIDD CREEK MINES LIMITED. REPORT ON SOIL AND TILL HEAVY MINERALS GEOCHEMICAL SURVEYS, AND GEOLOGICAL, GROUND IP AND RESISTIVITY SURVEYS, BY D. R. DUNCAN, 1984. 29 PAGES, 7 MAPS (GEOLOGICAL; HEAVY MINERALS GEOCHEMICAL; PROPERTY LOCATION; SOIL GEOCHEMICAL), IP PROFILES, RESISTIVITY PROFILES.

84-027

BASE METALS, LOWER BURLINGTON. CUVIER MINES INCORPORATED. REPORT ON A SOIL GEOCHEMICAL SURVEY, AND DRILLING, BY D. L. BLACK, 1984. 27 PAGES, 2 MAPS (DRILLHOLE LOCATION; PROPERTY LOCATION; SOIL GEOCHEMICAL), DRILLHOLE LOGS, DRILLHOLE SECTIONS.

84-028

BARITE, WALTON. CUVIER MINES INCORPORATED. REPORT ON GEOLOGY, A GROUND IP SURVEY, AND DRILLING, BY A. B. HUDGINS, 1984. 11 PAGES, 2 MAPS (DRILLHOLE LOCATION; GEOLOGICAL; PROPERTY LOCATION), DRILLHOLE LOGS, PSEUDO-SECTIONS, DRILLHOLE SECTIONS.

84-029

GOLD, LAWRENCETOWN. T. MCDONNELL. PROSPECTOR'S SKETCH MAP, BY T. MCDONNELL, 1984. 1 MAP (PROPERTY LOCATION).

84-030

GOLD, MONTAGUE. JACQUES WHITFORD AND ASSOCIATES LIMITED (FOR SEABRIGHT RESOURCES INCORPORATED). ENVIRONMENTAL REVIEW OF GOLD TAILINGS PROJECT FOR THE MONTAGUE AND OLDHAM GOLD DISTRICTS, BY J. A. AMIRAULT, V. K. NOWICKI, 1984. 100 PAGES, 4 MAPS (PROPERTY LOCATION; STREAM SEDIMENT SAMPLE LOCATION; STREAM WATER SAMPLE LOCATION; TAILINGS LOCATION), SEDIMENT PROPERTIES GRAPHS.

84-031

GOLD, SHEA LAKE. T. MCDONNELL. PROSPECTOR'S SKETCH MAP, BY T. MCDONNELL, 1984. 1 MAP (PROPERTY LOCATION).

84-032

GOLD, LOCHABER. K. RITCHIE. PROSPECTOR'S LETTER, BY K. RITCHIE, 1984. 1 PAGES, 1 MAP (PROPERTY LOCATION).

84-033

GOLD, LAGOON BROOK. T. MCDONNELL. PROSPECTOR'S SKETCH MAP, BY T. MCDONNELL, 1984. 1 MAP (PROPERTY LOCATION).

84-034

BASE METALS, EASTVILLE. SULPETRO MINERALS LIMITED. REPORT ON RE-INTERPRETATION OF DRILLHOLE DATA, BY A. L. SANGSTER, 1984. 2 PAGES, 1 MAP (DRILLHOLE LOCATION), DRILLHOLE SECTIONS.

84-035

BARITE, LORNE STATION. BLUESTACK RESOURCES LIMITED. REPORT ON A SOIL GEOCHEMICAL SURVEY, BY P. D. MCCULLOCH, 1984. 10 PAGES, 6 MAPS (GEOLOGICAL; INDUSTRIAL MINERAL LOCATION; METALLIC MINERAL LOCATION; PROPERTY LOCATION; SOIL GEOCHEMICAL).

84-036

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GOLD, CARIBOU. JAMES E. TILSLEY AND ASSOCIATED LIMITED (FOR LAKE MINE RESOURCES INCORPORATED AND JOHN LOGAN ENTERPRISES LIMITED). REPORT ON GEOLOGY, AND GROUND MAGNETIC AND GROUND VLF SURVEYS, BY J. E. TILSLEY, 1984. 19 PAGES, 7 MAPS (MAGNETIC, GROUND; MINE SURFACE PLANS; VLF, GROUND).

84-119

GOLD, UPPER SEAL HARBOUR. NAREX ORE SEARCH CONSULTANTS INCORPORATED (FOR ONITAP RESOURCES INCORPORATED). REPORT ON EXPLORATION AND DEVELOPMENT HISTORIES, GEOLOGY, AND DRILLING, BY P. BORN, 1984. 34 PAGES, 4 MAPS (DRILLHOLE LOCATION; GEOLOGICAL; MINE SURFACE PLANS; PROPERTY LOCATION), DRILLHOLE LOGS, MINE CROSS-SECTIONS, DRILLHOLE SECTIONS.

84-120

GOLD, FIFTEEN MILE STREAM. B. MACKENZIE. PROSPECTOR'S REPORT ON PANNING OF TILL, BY B. MACKENZIE, 1984. 11 PAGES, 2 MAPS (PROPERTY LOCATION).

84-121

GOLD, COCHRANE HILL. TRI-EXPLORATIONS LIMITED. REPORT ON A SOIL GEOCHEMICAL SURVEY, BY J. E. DAWE, 1984. 9 PAGES, 4 MAPS (PROPERTY LOCATION; SOIL GEOCHEMICAL).

84-122

GOLD, RENFREW. ECOLOGICAL AND RESOURCES CONSULTANTS LIMITED (FOR ANGLO CANADIAN MINING CORPORATION, E. TAYLOR AND E. HORNE). REPORT ON EXPLORATION AND DEVELOPMENT HISTORIES, GEOLOGY, SOIL AND HUMUS GEOCHEMICAL SURVEYS, GROUND VLF AND GROUND MAGNETIC SURVEYS, ASSAYING AND TRENCHING, BY W. E. HALE, C. LANGILLE, C. K. MAWER, 1984. 68 PAGES, 14 MAPS (DRILLHOLE LOCATION; EM, GROUND; MAGNETIC LINES LOCATION; PROPERTY LOCATION; ROCK GEOCHEMICAL; TRENCH LOCATION; VLF, GROUND), DRILLHOLE SECTIONS.

84-123

LIMESTONE, SCOTCH LAKE. F. M. ISENOR (FOR SCOTIA LIMESTONE AND A. A. MACDONALD). REPORT ON DRILLING, AND ORE RESERVES ESTIMATES, BY F. M. ISENOR, 1984. 56 PAGES, 3 MAPS (DRILLHOLE LOCATION; GEOLOGICAL), DRILLHOLE LOGS, DRILLHOLE SECTIONS.

84-124

GOLD, MOOSE RIVER. GEOTECH SURVEYS LIMITED (FOR SEABRIGHT RESOURCES INCORPORATED). REPORT ON GEOLOGY, EXPLORATION AND DEVELOPMENT HISTORIES, AND EXPLORATION PROPOSALS, BY W. B. ERVINE, 1984. 21 PAGES, 7 MAPS (METALLIC MINERAL LOCATION; PROPERTY LOCATION).

84-125

TUNGSTEN, SQUIRREL LAKE. KIDD CREEK MINES LIMITED. REPORT ON GEOLOGY, AND A TILL GEOCHEMICAL SURVEY, BY D. R. DUNCAN, 1984. 14 PAGES, 3 MAPS (GEOLOGICAL; METALLIC MINERAL LOCATION; PROPERTY LOCATION; TILL GEOCHEMICAL).

84-126

GOLD, BIG ASS LAKE. J. C. MYERS. PROSPECTOR'S NOTES, BY J. C. MYERS, 1984. 1 PAGE.

84-127

GOLD, MAHONEY BROOK. V. F. BENNETT. PROSPECTOR'S NOTES, BY V. F. BENNETT, 1984. 2 PAGES.

86-015

ZINC, STEWIACKE. U. S. BORAX. SB-1 DRILLHOLE LOG, BY W. B. BURTON, 1976. 22 PAGES, DRILLHOLE LOGS.

86-026

GOLD, COLDSTREAM BROOK. G. H. O. PARKER. REPORT ON GEOLOGY AND PIT DIGGING, BY G. H. O. PARKER, 1862. 10 PAGES.

OFFSHORE 75-001

PETROLEUM, BAY OF FUNDY. SOUTHEASTERN COMMONWEALTH DRILLING LIMITED, SCHLUMBERGER CANADA LIMITED AND CORE LABORATORIES CANADA LIMITED (FOR MOBIL OIL CANADA LIMITED). REPORT ON CHINAMPAS N-37 WELL HISTORY, FORMATION WATER AND CORE ANALYSES, DRILL STEM TESTS, AND GEOLOGY, BY M. E. KEOWN, B. W. BINT, 1975. 63 PAGES, 1 MAP (DRILLHOLE LOCATION), STRATIGRAPHIC CHARTS, DRILLHOLE LOGS, DUAL INDUCTION LOGS, SONIC LOGS, DENSITY LOGS, DIPMETER LOGS, PETROGRAPHIC LOGS.

OFFSHORE 82-001

PETROLEUM, BANQUEREAU BANK. EXLOG CANADA (FOR PETRO-CANADA RESOURCES). REPORT ON BANQUEREAU C-21 WELL PORE PRESSURES, DRILL STEM TESTS, AND FORMATION TESTS, 1982. 125 PAGES, 1 MAP (DRILLHOLE LOCATION), STRATIGRAPHIC COLUMNS, PETROGRAPHIC LOGS.

OFFSHORE 82-002

PETROLEUM, BANQUEREAU BANK. OTIS SERVICES (FOR PETRO-CANADA RESOURCES). REPORT ON BANQUEREAU C-21 WELL DRILL STEM TESTS, BY T. HENDRY, 1982. 196 PAGES.

OFFSHORE 83-001

PETROLEUM, BAY OF FUNDY. EXPLORATION DATA CONSULTANTS INCORPORATED (FOR CHEVRON STANDARD LIMITED). REPORT ON PROCESSING GRAVITY AND MAGNETIC SURVEY DATA, BY A. M. BERGNER, P. J. LAURIN, 1983. 35 PAGES, 1 MAP (GEOPHYSICAL SURVEYS INDEX), FREQUENCY DISTRIBUTION GRAPHS, GRAVITY PROFILES.

OFFSHORE 84-001

PETROLEUM, BROWNS BANK. EXLOG CANADA AND SCHLUMBERGER CANADA LIMITED (FOR PETRO-CANADA RESOURCES). REPORT ON BONNET P-23 WELL HISTORY, FORMATION AND WIRELINE TESTS, AND GAS ANALYSES, BY A. CRUM, A. MORLEY, 1984. 127 PAGES, 2 MAPS (DRILLHOLE LOCATION), STRATIGRAPHIC COLUMNS, DRILLHOLE LOGS, DUAL INDUCTION LOGS, DENSITY LOGS, SONIC LOGS, PETROGRAPHIC LOGS.

APPENDIX II

OPEN FILE REPORTS FOR 1986

86-010

STUDY OF MARKETS FOR AGGREGATE MATERIALS ACCESSIBLE FROM NOVA SCOTIA AND NEW BRUNSWICK, BY ADI LIMITED, 1986. 398 PAGES.

86-012

A STUDY OF THE INDUSTRIAL MINERALS USED IN OIL AND GAS EXPLORATION ON THE EASTERN CANADIAN OFFSHORE, BY JACQUES, WHITFORD AND ASSOCIATES LIMITED, CLELAND, DUNSMUIR CONSULTING LIMITED, 1986. 229 PAGES, 1 MAP (STUDY AREA LOCATION), STRATIGRAPHIC COLUMNS.

86-013

STUDY OF MARKETS FOR SILICA AND SILICA SANDS ACCESSIBLE FROM NOVA SCOTIA AND NEW BRUNSWICK, BY ADI LIMITED, 1986. 240 PAGES.

86-019

COMPILATION OF DRILLHOLES INFORMATION FROM OPEN ASSESSMENT REPORTS AVAILABLE TO THE END OF DECEMBER, 1985: CENTRAL NOVA SCOTIA - MAP SHEETS 11D, 11E, BY G. J. DEMONT, W. A. MCINTYRE, J. L. E. BATES, N. A. LYTTLE, G. M. FROTTEN, 1986. 322 PAGES, 1 MAP (NTS DIVISIONS LOCATION).

86-020

COMPILATION OF DRILLHOLES INFORMATION FROM OPEN ASSESSMENT REPORTS AVAILABLE TO THE END OF DECEMBER, 1985: EASTERN NOVA SCOTIA - MAP SHEETS 11F, 11G, 11J, 11K, 11N, BY G. J. DEMONT, W. A. MCINTYRE, J. L. E. BATES, N. A. LYTTLE, G. M. FROTTEN, 1986. 352 PAGES, 1 MAP (NTS DIVISIONS LOCATION).

86-021

COMPILATION OF DRILLHOLES INFORMATION FROM OPEN ASSESSMENT REPORTS AVAILABLE TO THE END OF DECEMBER, 1985: WESTERN NOVA SCOTIA - MAP SHEETS 20O, 20P, 21A, 21B, 21H, BY G. J. DEMONT, J. L. E. BATES, G. M. FROTTEN, W. A. MCINTYRE, N. A. LYTTLE, 1986. 236 PAGES, 1 MAP (NTS DIVISIONS LOCATION).

86-022

DETAILED GEOLOGICAL MAPS AND REPORT OF PARTS OF THE WESTERN COBEQUID HILLS, CUMBERLAND COUNTY, NOVA SCOTIA, BY G. PE-PIPER, D. J. W. PIPER, 1986. 32 PAGES, 9 MAPS (GEOLOGICAL; GEOLOGICAL SURVEYS INDEX).

86-039

AGRICULTURAL GYPSUM PROJECT, BY P. LUKE, 1986. 9 PAGES.

86-040

REPORT ON THE DRILLING OF NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY RIVERSIDE CORNER 85-1 DRILLHOLE, BY D. C. CARTER, R. C. BOEHNER, 1986. 13 PAGES, 1 MAP (DRILLHOLE LOCATION; GEOLOGICAL; GRAVITY), DRILLHOLE SECTIONS, TEMPERATURE PROFILES, NEUTRON LOGS, GAMMA RAY LOGS, DENSITY LOGS.

86-047

SITE LOCATION PLANS, BOREHOLE LOCATION PLANS AND BOREHOLE LOGS FOR AEROTECH BUISNESS PARK, HALIFAX COUNTY AND POINT EDWARD, CAPE BRETON COUNTY, BY NOLAN, DAVIS AND ASSOCIATES, 1986. 38 PAGES, 4 MAPS (DRILLHOLE LOCATION; GEOLOGICAL; PIT LOCATION; STUDY AREA LOCATION), DRILLHOLE LOGS, SOIL PROFILES.

86-054

THE U. K. EXPERIENCE ON THE EFFECTS OF OFFSHORE SAND AND GRAVEL EXTRACTION ON COASTAL EROSION AND THE FISHING INDUSTRY, BY R. W. DRINNAN, D. G. BLISS, 1986. 99 PAGES, PHOTOGRAPHS.

86-055

GEOSCAN GOLD BIBLIOGRAPHY - APPALACHIAN REGION, BY NATIONAL GEOSCAN CENTRE, 1986. 427 PAGES.

86-056

MANGANESE IN NOVA SCOTIA: A LISTING OF NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY AND GEOLOGICAL SURVEY OF CANADA REFERENCES GENERATED FROM THE GEOSCAN DATABASE, BY J. GILLESPIE-WOOD, N. A. LYTTLE, 1986. 32 PAGES.

86-063

INTERPRETATION OF A GRAVITY PROFILE ACROSS THE WINDSOR - KENNETCOOK AREA OF THE MINAS SUBBASIN OF NOVA SCOTIA, BY K. HOWELLS, 1986. 16 PAGES, 1 MAP (DRILLHOLE LOCATION; GRAVITY), GRAVITY PROFILES, CROSS-SECTIONS.

86-064

SUMMARY OF THE MAJOR LIMESTONE/DOLOMITE DEPOSITS OF NOVA SCOTIA, BY R. MACDONALD, 1986. 15 PAGES, 1 MAP (INDUSTRIAL MINERAL LOCATION).

86-066

NOVA SCOTIA FREESTONE DIMENSIONS - PAST, PRESENT AND FUTURE, BY L. BATTEN, G. B. DICKIE, 1986. 10 PAGES, 1 MAP (QUARRY LOCATION), PIE DIAGRAMS, HISTOGRAMS (FOR PRESENTATION TO THE MINING SOCIETY OF NOVA SCOTIA, INGONISH, NOVA SCOTIA, JUNE 27, 1986).

86-067

METALLURGICAL INFORMATION, SCOTSVILLE BARITE DEPOSIT, INVERNESS COUNTY, NOVA SCOTIA, BY C. COLE, M. A. K. GRICE, W. J. D. STONE, P. HANNON, R. K. COLLINGS, 1986. 25 PAGES.

86-069

SPRINGHILL COAL RECLAMATION PROJECT, COAL ANALYSES, BY S. CHESAL, 1986. 53 PAGES.

APPENDIX III

OPEN FILE MAPS FOR 1986

86-001

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE UPPER MUSQUODOBOIT MAP SHEET - 11E/02 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1183).

86-002

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE SHUBENACADIE MAP SHEET - 11E/03 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1184).

86-003

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE KENNETCOOK MAP SHEET - 11E/04 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1185).

86-004

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE BASS RIVER MAP SHEET (EAST HALF) - 11E/05 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1186).

86-005

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE BASS RIVER MAP SHEET (WEST HALF) - 11E/05 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1187).

86-006

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE TRURO MAP SHEET - 11E/06 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1138).

86-007

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE HOPEWELL MAP SHEET - 11E/07 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 PAGES, 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1189).

86-008

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE NEW GLASGOW MAP SHEET - 11E/10 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1190).

86-009

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE TATAMAGOUCHE MAP SHEET (EAST HALF) - 11E/11 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1191).

86-010

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE TATAMAGOUCHE MAP SHEET (WEST HALF) - 11E/11 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1192).

86-011

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE OXFORD MAP SHEET - 11E/12 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1244).

86-012

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE PUGWASH MAP SHEET - 11E/13 (1:50 000), BY

P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1245).

86-013

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE MALAGASH MAP SHEET - 11E/14 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1246).

86-014

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE PICTOU ISLAND MAP SHEET - 11E/15 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1247).

86-015

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE AMHERST MAP SHEET (EAST HALF) - 21H/16 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1248).

86-016

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE AMHERST MAP SHEET (WEST HALF) - 21H/16 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1249).

86-017

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE ALMA MAP SHEET - 21H/10 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1250).

86-018

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE SPRINGHILL MAP SHEET - 21H/09 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1251).

86-019

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE PARRSBORO MAP SHEET - 21H/08 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1252).

86-020

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE CAPE CHIGNECTO MAP SHEET - 21H/07 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1253).

86-021

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE MARGARETSVILLE MAP SHEET - 21H/03 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1262).

86-022

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE BERWICK MAP SHEET - 21H/02 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1263).

86-023

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE WOLFVILLE MAP SHEET (EAST HALF) - 21H/01 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1264).

86-024

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE WOLFVILLE MAP SHEET (WEST HALF) - 21H/01

(1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1265).

86-025

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE WINDSOR MAP SHEET - 21A/16 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1266).

86-026

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE GASPEREAU LAKE MAP SHEET - 21A/15 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1267).

86-027

STREAM SEDIMENT AND STREAM WATER GEOCHEMISTRY OF THE MOUNT UNIACKE MAP SHEET - 11D/13 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 16 MAPS (STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1268).

86-028

STREAM SEDIMENT, LAKE SEDIMENT, STREAM WATER AND LAKE WATER GEOCHEMISTRY OF THE MIRA MAP SHEET - 11F/16 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 20 MAPS (LAKE SEDIMENT GEOCHEMICAL; LAKE WATER GEOCHEMICAL; STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1269).

86-029

STREAM SEDIMENT, LAKE SEDIMENT, STREAM WATER AND LAKE WATER GEOCHEMISTRY OF THE GRAND NARROWS MAP SHEET - 11F/15 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 20 MAPS (LAKE SEDIMENT GEOCHEMICAL; LAKE WATER GEOCHEMICAL; STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1270).

86-030

STREAM SEDIMENT, LAKE SEDIMENT, STREAM WATER AND LAKE WATER GEOCHEMISTRY OF THE ST. PETERS MAP SHEET - 11F/10 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 20 MAPS (LAKE SEDIMENT GEOCHEMICAL; LAKE WATER GEOCHEMICAL; STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1271).

86-031

PROTECTED AND LIMITED USE LANDS IN NOVA SCOTIA (1:500 000), BY D. B. HOPPER, 1986. 1 MAP (LAND USE).

86-032

STREAM SEDIMENT, LAKE SEDIMENT, STREAM WATER AND LAKE WATER GEOCHEMISTRY OF THE FRAMBOISE MAP SHEET - 11F/09 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 20 MAPS (LAKE SEDIMENT GEOCHEMICAL; LAKE WATER GEOCHEMICAL; STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1291).

86-033

STREAM SEDIMENT, LAKE SEDIMENT, STREAM WATER AND LAKE WATER GEOCHEMISTRY OF THE LOUISBOURG MAP SHEET - 11G/13 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 20 MAPS (LAKE SEDIMENT GEOCHEMICAL; LAKE WATER GEOCHEMICAL; STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1292).

86-034

STREAM SEDIMENT, LAKE SEDIMENT, STREAM WATER AND LAKE WATER GEOCHEMISTRY OF THE GLACE BAY MAP SHEET - 11J/04 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 20 MAPS (LAKE SEDIMENT GEOCHEMICAL; LAKE WATER GEOCHEMICAL; STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1293).

86-035

STREAM SEDIMENT, LAKE SEDIMENT, STREAM WATER AND LAKE WATER GEOCHEMISTRY OF THE SYDNEY MAP SHEET - 11K/01 (1:50 000), BY P. J. ROGERS, M. A.

MACDONALD, 1986. 20 MAPS (LAKE SEDIMENT GEOCHEMICAL; LAKE WATER GEOCHEMICAL; STREAM SEDIMENT GEOCHEMICAL: STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1294).

86-036

STREAM SEDIMENT AND LAKE WATER GEOCHEMISTRY OF THE BADDECK MAP SHEET - 11K/02 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 20 MAPS (LAKE WATER GEOCHEMICAL; STREAM SEDIMENT GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1295).

86-037

STREAM SEDIMENT, STREAM WATER AND LAKE WATER GEOCHEMISTRY OF THE INGONISH MAP SHEET - 11K/09 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 20 MAPS (LAKE WATER GEOCHEMICAL; STREAM SEDIMENT GEOCHEMICAL; STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1296).

86-038

STREAM WATER GEOCHEMISTRY OF THE ST. ANNS HARBOUR MAP SHEET - 11K/07 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 3 MAPS (STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1300) (THIS MAP SUPPLEMENTS GSC OPEN FILE 988 AND NSDME OPEN FILE MAP 84-014).

86-039

STREAM WATER GEOCHEMISTRY OF THE BRAS D'OR MAP SHEET - 11K/08 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 3 MAPS (STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1301) (THIS MAP SUPPLEMENTS GSC OPEN FILE 989 AND NSDME OPEN FILE MAP 84-015).

86-040

STREAM WATER GEOCHEMISTRY OF THE GUYSBOROUGH MAP SHEET - 11F/05 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 3 MAPS (STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1302) (THIS MAP SUPPLEMENTS GSC OPEN FILE 990 AND NSDME OPEN FILE MAP 84-016).

86-041

STREAM WATER GEOCHEMISTRY OF THE CHEDABUCTO BAY MAP SHEET - 11F/06 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 3 MAPS (STREAM WATER GEOCHEMISTRY), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1303) (THIS MAP SUPPLEMENTS GSC OPEN FILE 991 AND NSDME OPEN FILE MAP 84-017).

86-042

STREAM WATER GEOCHEMISTRY OF THE PORT HAWKESBURY MAP SHEET - 11F/11 (1:50 000), BY P. J. ROGERS, M. A. ROGERS, 1986. 3 MAPS (STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1304) (THIS MAP SUPPLEMENTS GSC OPEN FILE 992 AND NSDME OPEN FILE MAP 84-018).

86-043

STREAM WATER GEOCHEMISTRY OF THE ANTIGONISH MAP SHEET - 11F/12 (1:50 000), BY P. G. ROGERS, M. A. MACDONALD, 1986. 3 MAPS (STREAM WATER GEOCHEMISTRY), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1305) (THIS MAP SUPPLEMENTS GSC OPEN FILE 993 AND NSDME OPEN FILE MAP 84-019).

86-044

STREAM WATER GEOCHEMISTRY OF THE LOCHABER MAP SHEET - 11E/08 (1:50 000), BY P. J. ROGERS, M. A. MACDONALD, 1986. 3 MAPS (STREAM WATER GEOCHEMICAL), HISTOGRAMS (GEOLOGICAL SURVEY OF CANADA, OPEN FILE, 1306) (THIS MAP SUPPLEMENTS GSC OPEN FILE 994 AND NSDME OPEN FILE MAP 84-020).

APPENDIX IV

NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY

PUBLICATIONS AND MAPS AVAILABLE FOR PURCHASE

PAPERS

Paper 76-1 Structural Model for the Saddle Reef and Associated Veins in the Meguma Group, Nova Scotia, by J. D. Keppie, 34 pages, 2 maps. ($3.00)

Paper 76-2 Geological Data Collection in the Nova Scotia Department of Mines, by J. D. Keppie and A. K. Chatterjee, 15 pages. ($0.50)

Paper 76-3 Interpretation of P.P.I. Radar Imagery of Nova Scotia, by J. D. Keppie, 31 pages, 1 map. ($1.25)

Paper 76-4 Geology, Geochemistry and Mineral Occurrences of the Northeast Margaree River Drainage Basin in parts of Inverness and Victoria Counties, Cape Breton, Nova Scotia, by B. E. MacNabb, J. H. Fowler and T. G. N. Covert, 30 pages, 12 maps. ($15.00)

Paper 76-5 Guide to the Invertebrate Fauna of the Windsor Group in Atlantic Canada, by R. G. Moore and R. J. Ryan, 57 pages. ($2.25)

Paper 77-1 Tectonics of Southern Nova Scotia, by J. D. Keppie, 34 pages (Reprinted 1980). ($3.00)

Paper 77-3 Plate Tectonic Interpretation of Paleozoic World Maps (with Emphasis on Circum-Atlantic Orogens and Southern Nova Scotia), by J. D. Keppie, 45 pages (Reprinted 1982). ($4.00 hardcopy, microfiche $1.50)

Paper 77-6 Sand and Gravel Resources of Pictou County, by J. H. Fowler and G. B. Dickie, 42 pages, 1 map. ($4.00)

Paper 77-7 Tungsten Mineralization in the Carbonate Rocks of the George River Group, Cape Breton Island, Nova Scotia, by A. K. Chatterjee, 26 pages. ($3.50)

Paper 78-1 Geology of the Ecum Secum Area, Halifax and Guysborough Counties, Nova Scotia, by D. McBride, 12 pages. ($1.00)

Paper 78-2 Age of Igneous Rocks along the Lennox Passage - St. Peters Lineament, Southern Cape Breton Island, by J. D. Keppie and P. K. Smith, 10 pages. ($1.00)

Paper 78-3 Geology of the Giant Lake Area, Southeastern Cape Breton Island, Nova Scotia, by P. K. Smith, 30 pages, 1 map. ($2.00)

Paper 78-4 Some Middle Devonian to Lower Carboniferous Rocks of Cape George, Nova Scotia, by J. D. Keppie, P. S. Giles, and R. C. Boehner, 37 pages. ($2.00)

Paper 78-5 Petrology of the Early Silurian Dunn Point and McGillivray Brook Formations, Arisaig, Nova Scotia, by J. D. Keppie, J. Dostal and M. Zentilli, 20 pages. ($1.00)

Paper 79-1 Petrology of the Late Precambrian Fourchu Group in the Louisbourg Area, Cape Breton Island, by J. D. Keppie, J. Dostal and J. B. Murphy, 18 pages. ($1.50)

Paper 79-2 Opencast Coal Reserves at Springhill, by B. Ward, 40 pages, 4 maps. ($4.50)

Paper 79-3 Geology of the Meat Cove Zinc Deposit, Cape Breton Island, by A. K. Chatterjee, 27 pages. ($2.00)

Paper 79-4 Minor and Trace Element Variations in Wisconsinan Tills, Eastern Shore Region, Nova Scotia, by R. R. Stea and J. H. Fowler, 30 pages, 3 maps. ($10.00)

Paper 79-5 Pleistocene Stratigraphy of the Miller Creek Section, Hants County, Nova Scotia, by R. Stea and D. Hemsworth, 16 pages. ($3.00)

Paper 79-6 Effects of Subsidence and Depositional Environment on the Formation of Lithotypes in a Hypautochthonous Coal of the Pictou Coalfield, by J. H. Calder, 23 pages. ($3.00)

Paper 79-7 Carbonate Banks of the Gays River Formation in Central Nova Scotia, by P. S. Giles, R. C. Boehner and R. J. Ryan, 57 pages, 1 map. ($4.00)

Paper 80-1 Geology of the Cape North Area, Northern Cape Breton Island, Nova Scotia, by A. S. Macdonald and P. K. Smith, 60 pages, 2 maps. ($5.00 hardcopy, microfiche $2.00)

Paper 81-1 The Fisset Brook Formation at Lowland Cove, Inverness County, Nova Scotia, by P. K. Smith and A. S. Macdonald, 18 pages. ($2.00 hardcopy, $1.00 microfiche)

Paper 81-2 Major Transgressive-Regressive Cycles in Middle to Late Visean Rocks of Nova Scotia, by P. S. Giles, 27 pages. ($2.00 hardcopy, $1.50 microfiche)

Paper 81-3 The Windsor Group of the Mahone Bay Area, Nova Scotia, by P. S. Giles, 51 pages, figure in back pocket. ($4.00 hardcopy, $1.50 microfiche)

Paper 81-4 Principles of Tectonic Mapping Based upon Plate Tectonic Theory, by J. D. Keppie, 11 pages. ($1.50 hardcopy, $1.00 microfiche)

Paper 82-1 Geology and Geochemistry of Selected Granitoid Plutons of Cape Breton Island, by S. M. Barr, G. A. O'Reilly and A. M. O'Beirne, 176 pages, 44 figures, 13 tables. ($8.00 hardcopy, $2.00 microfiche)

Paper 82-2 Metasomatic-Hydrothermal Mineral Deposits of the New Ross-Mahone Bay Area, Nova Scotia, by G. A. O'Reilly, E. J. Farley and M. H. Charest, 96 pages. ($5.00 hardcopy, $1.50 microfiche)

Paper 85-2 The Formation of Veins in Greenschist Facies Rocksand the Early Deformation of the Meguma Group, Eastern Nova Scotia, by B. H. O'Brien, 1985, 35 pages. ($3.00 hardcopy, $1.00 microfiche)

REPORTS

Report 75-1 Report of Activities of the Mineral Resources and Geological Services Division, 1974, by Nova Scotia Department of Mines, 75 pages. ($1.00)

Report 76-1 Drilling Logs of Government Core Drills, 1974, by I. MacDougall and D. W. Grimm, 73 pages. ($1.00)

Report 76-2 Mineral Resources Division, Report of Activities, 1975, 145 pages. ($3.00)

Report 76-3 Drilling Logs of Government Core Drills, 1975, by I. MacDougall and D. W. Grimm, 47 pages. ($1.00)

Report 77-1 Mineral Resources Division, Report of Activities, 1976, 207 pages. ($10.00)

Report 77-2 Superseded by Report 81-4.

Report 77-3 Drilling Logs of Government Core Drills, 1976, by I. MacDougall and D. W. Grimm, 33 pages. ($1.00)

Report 78-1 Mineral Resources Division, Report of Activities, 1977, 104 pages. ($4.00)

Report 78-2 Drilling Logs of Government Core Drills, 1977, by I. MacDougall and D. E. Polley, 72 pages. ($2.00)

Report 78-3 Superseded by Report 81-6

Report 78-4 Compilation of Isotopic Age Data of Nova Scotia, by J. D. Keppie and P. K. Smith, 54 pages, 7 maps. ($7.00)

Report 79-1 Mineral Resources Division, Report of Activities, 1978, 177 pages. ($6.00)

Report 79-2 Drilling Logs of Government Core Drills, 1978, by I. MacDougall and D. E. Polley, 54 pages. ($2.00)

Report 80-1 Mineral Resources Division, Report of Activities, 1979, 248 pages. ($7.00)

Report 80-2 Index to Drilling Logs of Government Core Drills, 1972-78, by N. A. Lyttle and J. Gillespie-Wood, 47 pages. ($3.00)

Report 80-3 Drilling Logs of Government Core Drills, 1979, by I. MacDougall and D. E. Polley, 68 pages. ($3.50 hardcopy, $1.50 microfiche)

Report 81-1 Mineral Resources Division, Report of Activities, 1980, 199 pages. ($8.00 hardcopy, $2.00 microfiche)

Report 81-2 Compilation of Igneous Chemical Analyses from Nova Scotia, up to 1978, compiled by J. D. Keppie, P. K. Smith and M. A. K. Grice, 114 pages. ($4.00 hardcopy, $2.00 microfiche)

Report 81-3 Drilling Logs of Government Core Drills, 1980, by I. MacDougall and D. E. Polley, 52 pages. ($3.50 hardcopy, $1.00 microfiche)

Report 81-4 Index to Assessment Reports 1864-1980, by N. A. Lyttle and J. Gillespie-Wood, 109 pages. ($10.00 hardcopy, $3.00 microfiche)

Report 81-5 Keyword Index to Assessment Reports, 1864-1980, by N. A. Lyttle and J. Gillespie-Wood. ($5.00 microfiche)

Report 81-6 Index to Publications, Open File Reports and Theses, 1862-1980, by N. A. Lyttle and J. Gillespie-Wood, 222 pages. ($10.00 hardcopy, $3.00 microfiche)

Report 81-7 Index to Drillhole and Well Data, 1862-1980, by N. A. Lyttle and J. Gillespie-Wood, 127 pages. ($10.00 hardcopy, $3.00 microfiche)

Report 82-1 Mineral Resources Division, Report of Activities, 1981, 139 pages. ($7.00 hardcopy, $2.00 microfiche)

Report 82-2 Index to Assessment Reports, 1981 (with Keyword Index), by N. A. Lyttle and J. Gillespie-Wood, 11 pages. ($3.00 hardcopy, $2.00 microfiche)

Report 82-3 Keyword Index to Publications in NSDME Report 81-6, by N. A. Lyttle and J. Gillespie-Wood. ($2.00 microfiche)

Report 82-4 Keyword Index to Open File Reports in NSDME Report 81-6, by N. A. Lyttle and J. Gillespie-Wood. ($1.00 microfiche

Report 82-5 Keyword Index to GSC Documents on Nova Scotia to 1980. ($2.00 microfiche)

Report 82-6 Drilling Logs of Government Core Drills, 1981, compiled by I. MacDougall and D. E. Polley, 1982, 60 pages. ($1.50 microfiche)

Report 82-7 Uranium in Nova Scotia: A Background Summary for the Uranium Inquiry, Nova Scotia, 122 pages & 2 maps. ($2.00 microfiche)

Report 83-1 Mines and Minerals Branch, Report of Activities, 1982, 404 pages. ($3.50 microfiche)

Report 83-2 Index to Assessment Reports 1982 (with Keyword Index), by N. A. Lyttle and J. Gillespie-Wood, 32 pages. ($2.00 microfiche)

Report 83-3 Drilling Logs of Government Core Drills, 1982, compiled by I. MacDougall and D. E. Polley, 1983, 38 pages. ($2.00 microfiche)

Report 84-1 Mines and Minerals Branch, Report of Activities, 1983, 352 pages. ($4.00 microfiche)

Report 84-2	Index to Assessment Reports 1983 (with Keyword Index), by N. A. Lyttle and J. Gillespie-Wood, 88 pages. ($8.50 hardcopy, $2.00 microfiche)
Report 84-3	Index to Publications and Open File Reports for 1981, 1982 and 1983 (with Keyword Index), by N. A. Lyttle and J. Gillespie-Wood, 152 pages. ($13.50 hardcopy, $3.50 microfiche)
Report 84-4	Keyword Index to Theses in Report 81-6, Index to Publications, Open File Reports and Theses 1862-1980, by D. B. Hopper, J. Gillespie-Wood and N. A. Lyttle. ($5.00 microfiche)
Report 84-5	Drilling Logs of Government Core Drills, 1983, compiled by I. MacDougall and D. E. Polley, 1983, 38 pages. ($3.50 hardcopy, $2.00 microfiche)
Report 84-6	Bibliography of the Surficial Geology of Nova Scotia and the Offshore (with Radiocarbon Date List), by R. R. Stea and V. J. Brisco. 128 p. ($6.00 hardcopy, $2.00 and $4.00 microfiche)
Report 85-1	Mines and Minerals Branch, Report of Activities, 1984, 232 pages. ($10.00 hardcopy, $3.00 microfiche)
Report 85-2	Index to Assessment Reports 1984 (with Keyword Index), by N. A. Lyttle and J. Gillespie-Wood, 18 pages. ($5.00 hardcopy, $2.00 microfiche)
Report 85-3	Index to Publications, Open File Reports, and Open File Maps for 1984 (with Keyword Index), by N. A. Lyttle and J. Gillespie-Wood, 94 pages. ($10.00 hardcopy, $4.00 microfiche)
Report 85-4	Drilling Logs of Government Core Drills, 1984, compiled by I. MacDougall and D. E. Polly, 1984, 32 pages. ($3.50 hardcopy, $2.00 microfiche)
Report 86-1	Mines and Minerals Branch, Report of Activities, 1985, 374 p. ($12.00 hardcopy, $3.50 microfiche)
Report 86-2	Index to Assessment Reports 1981-1985 (with Keyword and Map Index) by N. A. Lyttle, J. Gillespie-Wood, G. M. Frotten and M. J. Fraser-MacKinnon, 178 p. ($20.00 hardcopy, $8.00 microfiche)
Report 86-3	Drilling Logs of Government Core Drills, 1985, compiled by I. MacDougall and D. E. Polley, 21 p. ($3.50 hardcopy, $2.00 microfiche)

MEMOIRS

Memoir 4	The Older Paleozoic of Pictou County, Nova Scotia, by R. H. Maehl, 1961, 109 pages, appendix, 1 map. ($3.00)
Memoir 5	Pleistocene Geology of the Annapolis Valley, Nova Scotia, by C. F. Hickox, 1962, 36 pages, 1 map. ($2.00)
Memoir 7	The Geology of the George River Series, Cape Breton, by G. C. Milligan, 1970, 111 pages, 7 maps. ($4.50)

BULLETINS

Bulletin 1	Port Hawkesbury Project - Geology, Geochemistry and Groundwater Investigations of Southwest Inverness and Richmond Counties, Nova Scotia, by F. S. Shea and J. D. Wallace, 1962, 73 pages, 5 maps. ($2.00)
Bulletin 2 (Part 1)	Limestones and Dolomites of Nova Scotia, Part I - Cape Breton Island, by F. S. Shea and D. A. Murray, 1969, 300 pages, 1 map. ($4.00)
Bulletin 2 (Part 2)	Limestones and Dolomites of Nova Scotia, Part II - Antigonish, Guysborough, Pictou, and Cumberland Counties, by D. A. Murray, 1975, 155 pages. ($6.50)
Bulletin 3	Assessment of Peat Moss Occurrences in Guysborough, Antigonish, Pictou, Colchester and Cumberland Counties, Nova Scotia, by D. R. Sutherland and F. S. Shea, 1976, 301 pages. ($7.00)

Bulletin 4 Barite, Celestite and Fluorite in Nova Scotia, by G. W. Felderhof, 1978, 463 pages. ($13.00)

Bulletin 5 Salt and Potash Resources in Nova Scotia by R. C. Boehner, 1986, 346 pages, 1 map. ($17.00 hardcopy, $5.00 microfiche)

INFORMATION SERIES

No. 1 Geology, Minerals and Mining in Nova Scotia, by J. M. Richardson and D. J. Gregory, 1976, 22 pages. (Free)

No. 2 A History of Coal Mining in Nova Scotia, compiled by D. J. Gregory, 1978, 41 pages. (Free)

No. 3 Program and Summaries, Fourth Annual Open House and Review of Activities of the Mineral Resources Division, 1980, Nova Scotia Department of Mines and Energy, 106 pages. ($1.00 microfiche)

No. 4 Program and Summaries, Fifth Annual Open House and Review of Activities, 1981, Nova Scotia Department of Mines and Energy, 51 pages. ($1.00 microfiche)

No. 5 Program and Summaries, Sixth Annual Open House and Review of Activities, 1982, Nova Scotia Department of Mines and Energy, 69 pages. ($1.00 hardcopy, $1.00 microfiche)

No. 6 Program and Summaries, Seventh Annual Open House and Review of Activities, 1983, Nova Scotia Department of Mines and Energy, 123 pages. ($2.00 microfiche)

No. 7 Program and Summaries, Eigth Annual Open House and Review of Activities, 1984, Nova Scotia Department of Mines and Energy, 115 pages. ($2.00 hardcopy, $1.00 microfiche)

No. 8 Coal in Nova Scotia by J. H. Calder, 1985, 79 pages. ($5.00)

No. 9 Program and Summaries, Ninth Annual Open House and Review of Activities, 1985, Nova Scotia Department of Mines and Energy, 136 pages. ($3.00 hardcopy, $1.50 microfiche)

No. 12 Program and Summaries, Tenth Annual Open House and Review of Activities, 1986, Nova Scotia Department of Mines and Energy, 206 pages. ($5.00 hardcopy, $2.00 microfiche)

INFORMATION CIRCULARS

No. 1 Directory of Goods and Services for Exploration Companies, by H. V. Donohoe, Jr. and M. E. Devanney. (Free)

No. 2 Mineral Rights, Landowners and Mineral Exploration, by H. V. Donohoe, Jr. and M. E. Devanney. (Free)

No. 3 A Walking Tour of Rocks, Minerals and Building Stones in Downtown Halifax, by M. E. Devanney, H. V. Donohoe, Jr., S. Doyle and M. Shaw. (Free)

No. 4 Nova Scotia Gold, by M. E. Devanney and S. Doyle. (Free)

No. 7 Rocks, Minerals and Landforms of Point Pleasant Park, by B. McBournie, H. V. Donohoe, Jr. and M. E. Devanney. (Free)

REPRINT SERIES

No. 1 Paleozoic Volcanic Rocks of Nova Scotia, by J. D. Keppie and J. Dostal, 1980, 8 pages. Reprinted from - Proceedings: "The Caledonides in the U.S.A." I.G.C.P. Project 27: Caledonide Orogen. ($1.00)

No. 2 Granitoid and Other Plutonic Rocks of Nova Scotia, by D. B. Clarke, S. M. Barr and H. V. Donohoe, 1980, 10 pages. Reprinted from - Proceedings: "The Caledonides in the U.S.A." I.G.C.P. Project 27: Caledonide Orogen. ($1.00)

Reprint 81-1 Determination of Gold in Natural Waters at the Parts-per-Trillion (pg cm^{-3}) level, by R. R. Brooks, A. K. Chatterjee and D. E. Ryan, 7 pages. Reprinted from Chemical Geology, v. 33, 1981. ($1.00 microfiche)

Reprint 82-1 Observations on the Ichnology of the Meguma Group (?Cambro-Ordovician) of Nova Scotia, by R. K. Pickerill and J. D. Keppie, 1981, 9 pages. Reprinted from Maritime Sediments and Atlantic Geology, v. 17, 1981. ($1.50 hardcopy, $1.00 microfiche)

Reprint 82-2 A Rapid Method for the Determination of Gold and Silver in Sulfide Ores and Rocks, by R. R. Brooks, J. Holzbecher, D. E. Ryan, H. F. Zhang and A. K. Chatterjee, 1981, 4 pages. Reprinted from Atomic Spectroscopy, v. 2, no. 5, 1981. ($1.00 microfiche)

Reprint 82-3 Geochemistry and the Distribution of Uranium and Thorium in the Granitoid Rocks of the South Mountain Batholith, Nova Scotia, by A. K. Chatterjee and G. K. Muecke, 17 pages. Reprinted from Uranium in Granites: Geological Survey of Canada, Paper 81-23, p. 11-17, 1982. ($1.50 hardcopy, $1.00 microfiche)

Reprint 82-4 The Minas Geofracture, by J. D. Keppie, 1982. Reprinted from Geological Association of Canada, Special Paper 24, 18 pages. ($2.00 hardcopy, $1.00 microfiche)

Reprint 82-5 The Distribution of Gold in Rocks and Minerals of the Meguma Group of Nova Scotia, Canada, by R. R. Brooks, A. K. Chatterjee, P. K. Smith, D. E. Ryan and H. F. Zhang, 9 pages. Reprinted from Chemical Geology, v. 35, 1982. ($1.00 microfiche)

Reprint 83-1 A Multivariate Approach to Geochemical Distinction Between Tin-specialized and Uranium-specialized Granites of Southern Nova Scotia, by A. K. Chatterjee, D. F. Strong, and G. K. Muecke. Reprinted from Canadian Journal of Earth Sciences, v. 20, 1983. ($1.50 hardcopy, $1.00 microfiche)

Reprint 83-2 Uranium and Thorium in Paleozoic Rhyolites of Nova Scotia, by J. Dostal, C. Dupuy, and J. D. Keppie. Reprinted from Canadian Journal of Earth Sciences, v. 20, no. 2, 1983. ($1.50 hardcopy, $1.00 microfiche)

Reprint 84-1 Proceedings of the Deformation Study Group, Caledonide Orogen Project, by J. D. Keppie, D. G. Gee, D. Roberts, D. Powell, M. D. Max, P. Osberg, A. Pique, and J. P. Lecorche. Reprinted from Regional Trends in the Geology of the Appalachian-Caledonian - Hercynian - Mauritanide Orogen, edited by P. E. Schenk, 1983, p. 275-278. ($1.50)

Reprint 84-2 Times of Deformation in the Canadian Appalachians, by J. D. Keppie, P. St. Julien, C. Hubert, J. Beland, B. Skidmore, L. R. Fyffe, A. A. Ruitenberg, S. R. McCutcheon, H. Williams and J. Bursnall. Reprinted from Regional Trends in the Geology of the Appalachian-Caledonian - Hercynian - Mauritanide Orogen, edited by P. E. Schenk, 1983, p. 307-313. ($1.50)

Reprint 84-3 Petrology and Geochemistry of Devono-Carboniferous Volcanic Rocks in Nova Scotia, by J. Dostal, J. D. Keppie and C. Dupuy. Reprinted from Maritime Sediments and Atlantic Geology, 19, 1983, p. 59-71. ($1.50)

Reprint 84-4 The Appalachian collage; J. D. Keppie; in The Caledonide Orogen-Scandinavia and Related Areas edited by D. G. Gee and B. A. Stuart, 1985, p. 1217-1226. ($2.00 hardcopy, microfiche $1.00)

Reprint 84-5 Mining in Nova Scotia-Past and Present, by Howard V.Donohoe, Jr. Reprinted from CIM Directory 1984, p. 1-24. ($1.50 hardcopy, $1.00 microfiche)

Reprint 84-6 Discriminant and Factor Analysis of Geochemical Data from Granitoid Rocks Hosting the Millet Brook Uranium Mineralization, South Mountain Batholith, Nova Scotia, by A. K. Chatterjee and D. F. Strong. Reprinted from Uranium, 1, 1984, p. 289-305. ($3.00)

Reprint 85-1 Rare-earth and Other Element Variations in Greisensand Granites Associated with East Kemptville Tin Deposit, Nova Scotia, Canada, by A. K. Chatterjee and D. F. Strong. Reprinted from Transactions/ Section B. of the Institution of Mining and Metallurgy, v. 93, 1984, p. B59-B70. (OUT OF PRINT)

Reprint 85-2 Cambrian Volcanism in Nova Scotia, Canada by J. B.Murphy, K. Cameron, J. Dostal, J. D. Keppie and A. J. Haynes; in Canadian Journal of Earth Sciences, v. 22, no. 4, 1985, p. 599-606. ($1.50 hardcopy, $1.00 microfiche)

Reprint 86-1 The Petrology, Geochemistry and Economic Potential of the Musquodoboit Batholith, Nova Scotia, by M. A. MacDonald and D. B. Clarke; in Canadian Journal of Earth Sciences, v. 22, p. 1633-1642.

Reprint 86-2 Upper Carboniferous Strata of the Tatamagouche Syncline, Cumberland Basin, Nova Scotia, by R. J. Ryan, in Current Research, Part B, Geological Survey of Canada, Paper 85-1B, p. 481-490.

Reprint 86-3 Review of Some Chemical and Mineralogical Characteristics of Granitoids Rocks Hosting Sn, W, U, Mo deposits in Newfoundland and Nova Scotia, by A. K. Chatterjee and D. F. Strong, in High Heat Production (HHP) Granites, Hydrothermal Circulation and Ore Genesis, eds. R. Taylor and D. F. Strong; The Institution of Mining and Metallurgy, Cornwall England, 1985, p. 489-516.

ECONOMIC GEOLOGY SERIES

EGS74-1 Geology and Trace Elements of Nova Scotia Manganese Occurrences in Nova Scotia, by D. G. Bishop and J. D. Wright, 1974, 255 pages. ($7.50)

EGS75-1 Iron Deposits of Nova Scotia, by J. D. Wright, 1975, 54 pages, 1 map. ($6.00)

MISCELLANEOUS PUBLICATIONS

Core Drilling in Nova Scotia with Government Drills, 1871-1966, 176 pages. ($2.00)

Core Drilling in Nova Scotia with Government Drills, 1967-1971, 49 pages. ($1.00)

Drilling Logs of Government Core Drills, 1958-1973. Prior to 1958 in Mines Reports; after 1973 in NSDME Reports. ($16.00, $1.00 each for individual years)

Possibilities for Occurrence of Petroleum Reservoirs in Nova Scotia, by W. A. Bell, 1958, 177 pages. ($1.00)

Metallic Mineral Occurrences Recorded in the Province of Nova Scotia, by Nova Scotia Department of Mines, 1966, 350 pages. ($4.00)

Handbook for Companies Planning Offshore Drilling, by Nova Scotia Department of Mines, 1969, 23 pages. ($0.50)

Clay and Sand Deposit at Elmsvale, Halifax County, Nova Scotia, by J. H. Fowler, 1972, 62 pages, drillhole sections. ($2.50)

Geology of the Middle River and Baddeck Forks Map Areas, Victoria County, Nova Scotia, by B. E. Jones and T. G. N. Covert, 1972, 124 pages, 5 maps. ($5.00)

Petroleum Exploration in Nova Scotia, by W. Potter and T. Dexter, 1974, 15 pages. ($1.00)

Bibliography of the Geology of Nova Scotia, by D. J. Gregory, 1975, 237 pages. ($4.00 microfiche)

Oil and Gas Exploration in Nova Scotia, 1982-83, by Nova Scotia Department of Mines and Energy, 1983. ($2.00)

Nova Scotia: Oil and Gas Report 1984. ($2.00)

An Introduction to the Offshore, 1985, 21 pages. (FREE)

Nova Scotia; Oil and Gas Report, 1985, 50 pages. ($2.00)

Nova Scotia: Oil and Gas Report, 1986, 51 pages. ($2.00)

ACTS

Mineral Resources Act, by Nova Scotia Department of Mines and Energy, 1975, 61 pages. ($1.50)

Regulations under the Mineral Resources Act, 1975,

- Work on Mineral Rights, 4 pages. ($0.25)

- Boundaries of Mineral Lands, 4 pages. ($0.25)
- Schedule of Fees, 1 page. ($0.25)
- Royalities, 1 page. ($0.25)

Metalliferous Mines & Quarries Regulation Act, by Nova Scotia Department of Mines and Energy, 1967, 83 pages. ($3.00)

Coal Mines Regulation Act, by Nova Scotia Department of Mines and Energy, 1967, 143 pages. ($3.00)

Petroleum Resources Act, by Nova Scotia Department of Mines and Energy, 1984. ($3.00)

Gypsum Mining Income Tax Act, by Nova Scotia Department of Mines and Energy, 1954, 13 pages. ($1.00)

An Act Respecting Exploration for the Underground Storage of Gas, by Nova Scotia Department of Mines and Energy, 1970, 6 pages. ($1.00)

MAPS

Preliminary Map 78-1 Geology Map of the Cobequid Highlands, by H. V. Donohoe and P. I. Wallace, scale 1:125 000. ($3.50)

Geological Map of Nova Scotia, by J. D. Keppie, scale 1:500 000, 1979, with metamorphic and structural map inserts, by J. D. Keppie and G. K. Muecke, scale 1:1 000 000. ($2.00)

Geological Map of Nova Scotia, Metallic Mineral Occurrence Edition, by J. D. Keppie, D. J. Gregory, A. K. Chatterjee and N. A. Lyttle, scale 1:500 000, 1979, with structural and metamorphic map inserts, by J. D. Keppie and G. K. Muecke, scale 1:1 000 000. ($2.50)

Geological Map of Nova Scotia, Bouguer Gravity Anomaly Edition, by J. D. Keppie, scale 1:500 000, 1979, with metamorphic and structural map inserts, by J. D. Keppie and G. K. Muecke, scale 1:1 000 000. ($5.00)

Tectonic Map of Nova Scotia, by J. D. Keppie, scale 1:500 000, 1982. ($5.00)

Metallogenic Map of Nova Scotia, by A. K. Chatterjee, scale 1:500 000, 1983. ($1.00)

Folio of Geological Maps of Nova Scotia - Includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. ($10.00)

A Map Book of the Province of Nova Scotia, Geological Edition, scale 1:250 000, 1979, 46 pages. ($1.00)

Index of Map Book of Nova Scotia, 1979. ($5.00)

Claims maps (compilation) of Nova Scotia, scale 1:500 000 (1 white print). ($2.00)

Reservation Grid System for Petroleum Licenses, Onshore, scale 1:500 000 (1 white print). ($2.00)

Reservation Grid System for Petroleum Licenses, Offshore, scale 1:1 500 000 (1 white print). ($3.50)

Geological Highway Map of Nova Scotia by Jonathan P. Bujak and Howard V. Donohoe, Jr., scale 1:633 600, 1980. (Atlantic Geoscience Society, Special Publication Number 1) ($9.00)

A Map Book of the Province of Nova Scotia, scale 1:250 000, revised edition 1985 with index of geographical names, 39 pages.

Map 81-1	Pleistocene Geology and Till Geochemistry, Central Nova Scotia, (Sheet 4; Sheets 1, 2 and 3 in Paper 79-4), by R. R. Stea and J. H. Fowler, scale 1:100 000. ($3.50)
Map 82-1	Pleistocene Geology and Till Geochemistry of South Central Nova Scotia (Sheet 6), by R. R. Stea, scale 1:100 000. ($3.50)
Map 82-2	Antigonish Basin, by R. C. Boehner and P. S. Giles, scale 1:50 000. ($3.00)
Map 82-3	Eureka Area, by P. S. Giles, scale 1:50 000. ($3.00)
Map 82-4	Shubenacadie and Musquodoboit Basins, by P. S. Giles and R. C. Boehner, scale 1:50 000. ($5.00)
Map 82-5	Geology Map of the Northern Antigonish Highlands, Nova Scotia, by J. B. Murphy, J. D. Keppie and A. Hynes, scale 1:50 000. ($4.00)
Map 82-6*	Advocate Harbour-Port Granville Region, by H. V. Donohoe Jr. and P. I. Wallace, scale 1:50 000. ($8.00)
Map 82-7*	Parrsboro-Five Islands Region, by H. V. Donohoe Jr. and P. I. Wallace, scale 1:50 000. ($8.00)
Map 82-8*	Economy River-Folly Lake Region, by H. V. Donohoe Jr. and P. I. Wallace, scale 1:50 000. ($8.00)
Map 82-9*	Debert - Mt. Thom Region, by H. V. Donohoe Jr. and P. I. Wallace, scale 1:50 000. ($8.00)
Map 82-10	Pleistocene Geology and Till Geochemistry of Southwestern Nova Scotia (Sheets 7 + 8), by R. R. Stea and D. R. Grant, scale 1:100 000. ($8.00)
Map 83-1	Geological Map of the Hantsport Area, Nova Scotia, compilation and geology by S. A. Ferguson, scale 1:25 000. ($5.00)
Map 83-2	Calculated Vertical Magnetic Gradient Map of the Cape Breton Highlands, Inverness, and Victoria Counties, Nova Scotia, scale 1:125 000. ($5.00)
Map 83-3	Salt and Potash Resources of Nova Scotia, by R. C. Boehner, scale 1:500 000. ($4.00)
Map 83-4	Geological Map of the Red River Anorthosite Complex, Inverness and Victoria Counties, Nova Scotia, by P. K. Smith and A. S. Macdonald, scale 1:125 000. ($1.50)
Map 84-1	Geological Map of the Cochrane Hill Open-Pit Gold Deposit, Guysborough County, Nova Scotia, by P. K. Smith, scale 1:66.7. ($8.00)
Map 85-1	Industrial mineral commodities map of the Province of Nova Scotia; John H. Fowler (compiler), 1985; scale 1:500 000. ($5.00)
Map 85-2	Loch Lomond Basin and Glengarry Half Graben by R. C. Boehner and G. Prine, scale 1:50 000. ($5.00)
Map 85-3	Aggregate Resources, Cape Breton Island by W. J. Wright, scale 1:125 000 (locates and names aggregate pits and quarries). ($3.00)
Map 85-4 85-5 85-6	Aggregate Resources, Cape Breton Island, by W. J. Wright, scale 1:125 000. ($3.00 ea.)

***Note:** Maps 82-6 to 82-9 may be purchased individually or as a set for $25.00

Map 86-1 Geological Map of the Sydney Basin, Cape Breton Island, Nova Scotia, by R. C. Boehner and P. S. Giles, scale 1:50 000. ($5.00)

OTHER PUBLICATIONS AND MAPS AVAILABLE FOR PURCHASE

Malagash Salt, compiled and edited by John R. MacQuarrie, c. 1975,1981. ($5.00)

Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985)

Trip No. 1 Appalachian Geotraverse (Canadian Mainland); J. D. Keppie, K. Currie, J. B. Murphy et al. ($15.00)

Trip No. 3 Repeated Orogeny, Faulting and Stratigraphy in the Cobequid Highlands, Avalon Terrain of Northern Nova Scotia; H. V. Donohoe, Jr., P. Wallance. ($8.00)

Trip No. 10 Igneous and Metamorphic Geology of the Cape Breton Highlands; S. M. Barr, R. A. Jamieson, R. D. Raeside. ($5.00)

Trip No. 11 Turbidite-Hosted Gold Deposits, Meguma Domain, Eastern Nova Scotia; P. K. Smith, S. J. Haynes, B. E. Jones. ($7.00)

Trip No. 14 Lithostratigraphic, Physical Diagenetic and Economic Aspects of the Pennsylvanian Permian Transition Sequence of Prince Edward Island and Nova Scotia; H. W. van de Poll, J. R. Degrace, R. J. Ryan. ($7.00)